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Evaluation the relationship between polymorphism of galactose mutarotase gene by creating jaw sound in patients with temporomandibular disorder (TMD)

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ABSTRACT

Objective: One of the concerns of dentists is the referral of patients with temporomandibular problems. Temporomandibular joint disorders (TMD) is a complex multifactorial clinical problem that involves masticatory muscles, temporomandibular joint and related structures. This complication is one of the three common chronic pains after headache and low back pain, which can manifest as pain in the temporomandibular region and limitation in joint movements, or even as clicking, crepitus, and popping sounds during temporomandibular joint movements. For the first time, the american association for oral pain (AAOP) proposed the role of genetic factors in the development of TMD. It is thought that a complex disorder such as TMD is multidimensional and can be subjected to environmental conditions as well as multiple gene polymorphisms. Identification of single nucleotide polymorphisms in the human genome can play an important role in clinical setting for diagnosis, prognosis and therapeutic interventions in various diseases including TMD. The aim of this study was to evaluate the relationship between polymorphism of galactose mutarotase gene by creating jaw sound in patients with temporomandibular disorder in a population with high similarity to the whole Iranian population and using the results in prevention and targeted treatment of affected patients.

Study Design: 101 patients with TMD using DC/TMD criteria among those referred to Tehran University School of Dentistry and 103 healthy subjects for TMD that have age and gender matched were selected to control groupfrom those referring to the Oral and Maxillofacial Diseases and Oral and Maxillofacial Pain departments. Blood samples were taken in 5cc and DNA extracted from the blood of both groups by applying the technique PCRARMS in terms of polymorphism rs4776783 in Galm gene were Compared.

Results: 101 patients with TMD along with 103 healthy individuals without a history of TMD were evaluated to investigate rs4776783 polymorphism in GALM gene. The average age of the patients was 35.92, and 21 were men and 80 were women. According to the questionnaire, 61 people felt the sound in their jaw while moving. On the other hand, according to the TMD/DC criterion, the number of people who have crepitus in the right and left jaws is equal. The average age of the patients was 35.92, and 21 were men and 80 were women. According to the questionnaire, 61 people felt the sound in their jaw while moving. On the other hand, according to the TMD/DC criterion, the number of people who have crepitus in the right and left jaws is equal. The low prevalence of crepitation with p=0.734 has a significant relationship with the genotype of people.

Conclusion: This study showed that there is a significant relationship between the rs4776783 polymorphism in Galm gene and the occurrence of temporomandibular disorder (TMD), jaw sound and pain in many masticatory muscles such as lateral pterygoid and temporal. Therefore, it can be concluded that TMD has a genetic basis.

Keywords: Galactose mutarotase; GALM; Temporomandibular disorder; Polymorphism.

Introduction

Temporomandibular joint disorders (TMD) is a complex multifactorial clinical problem that involves masticatory muscles, temporomandibular joint and related structures [1]. This complication is one of the three most common chronic pains after headache and back pain, and according to the causes and clinical

examinations, it is defined as follows: the presence of any functional abnormality in different parts of the face and neck that has specific clinical symptoms such as pain, limitation in the movement and operation of the lower jaw and the sound from the temporomandibular joint [2-1], which can be accompanied by pain in the temporomandibular region and limitation in joint movements, or with clicking, cryptic, and popping sounds during movement. In the popular definition, the clicking sound refers to the sound of "knocking" and is generally caused by stress (it can be periodic or indicate a more acute disorder), while the popping sound is caused by a reversible disorder (the clicking sound is partially which the people around can also hear) and its cause can be an internal irregularity, tumor or stophyte, while cryptos has a sound similar to "hissing" and is caused by an irreversible disorder and its causes can be caused by osteoarthritis disorders.

For the first time, the american association of oral pain (AAOP) proposed the role of genetic factors in the occurrence of TMD. There are no exact statistics available about the prevalence of these disorders in Iran, and its rate has been reported to vary from 18.7% to 51.5% [2-4]. Since the temporomandibular joint is one of the most used joints in the body and humans move this joint 2000-1500 times a day and it is one of the organs affected by the occurrence of emotions and nervous behaviors in humans, therefore this part of the body may be under psychological pressure in certain situations and these pressures cause wear. dentition, loss of height of the teeth or premature fatigue of the muscles of the masticatory system, for this reason nowadays, the presence of psychological problems in these abnormalities is given great importance [73]. The causes of this disease include parafunctional actions (clenching and bruxism at night, sucking thumbs and fingers during the day), trauma in the form of microtrauma or macrotrauma, stress, growth and development disorders (genetic diseases) and developmental anomalies of the temporomandibular joints, including Condyle hypoplasia, systemic problems are internal disorders, rheumatic diseases and occlusion [7,5]. Currently, TMD is related to several etiological factors such as: malocclusion, internal temporal joint disorder, disc problem, dental problem, stress, trauma, parafunction, age, gender [3-6]. It is thought that a complex complication like TMD is a multifaceted complication and can be affected by environmental conditions and multiple gene polymorphisms [10]. Identification of single nucleotide polymorphism in the human genome can play an important role in carrying out appropriate clinical measures for diagnosis, prognosis and therapeutic interventions in various diseases, including TMD. Identifying SNPs sensitive to TMD can play an important role in diagnosing hereditary types of this condition and providing treatment and care recommendations to prevent future generations from suffering or reduce the severity of the disease [11,8]. To investigate a type of genetic changes, there is a need to design epidemiological studies on common allelic types. Studies on genetic factors are highly affected by false negative association when evaluating SNPs independently. Because each of these SNPs may play a very small role in the development of a complex and multifactorial disease such as TMD [12-14]. Considering the multifactorial nature of TMD and the role of cumulative risk factors such as genetic factors in the development of TMD, it can be said that in order to investigate the independent effects of each of these risk factors, there is a need to conduct separate studies [13,9].

GALM encodes galactose motorotase. Galactose mutarotase catalyzes the conversion of beta-d-galactose to alpha-d-galactose 8, which is important in the metabolism of carbohydrates and the production of complex oligosaccharides. Galactose motorotase may affect regional neurophysiology, leading to local increases in serotonin secretion and in 5-HTT9 membrane permeability, thereby increasing [11C] DASB-BPND. Galactose mutarotase may also be involved in N-glycosylation, which is important for 5-HTT10 surface expression [69]. The GALM gene was first reported in Escherichia coli in 1965. However, the gene encoding the human enzyme was identified in 2003 and the protein product was identified. This enzyme has been isolated from bacteria, plants and animals and is present in the cytoplasm of most cells. The polypeptide chain is folded in a complex arrangement of 29 β-strands, 25 classic turns and 2 small α-helices. There are two cis-peptide bonds at Arg-78 and Pro-103. The sugar ligand is located in a shallow cleft and is surrounded by Asn-81, Arg-82, His-107, His-176, Asp-243, Gln-279, and Glu-307. Both side chains of Glu-307 and His-176 are well positioned to act as a catalytic base and acid, respectively. These residues are highly conserved among galactose mutarotases. The molecular architecture of these enzymes differs mainly in the loop regions that connect the first two β strands. During normal galactose metabolism, β d -galactose is converted to glucose 1-phosphate through the action of four enzymes that make up the Leloir pathway. In the first step of this pathway, β-d-galactose is converted to alpha-d-galactose through the action of galactose

motorotase. The second step involves the phosphorylation of alpha-d-galactose to galactose 1-phosphate by galactokinase. Galactose 1-phosphate uridyltransferase catalyzes the third step by transferring a UMP group from UDP-glucose to galactose 1-phosphate, thereby producing glucose 1-phosphate and UDP-galactose. To complete the pathway, UDP-galactose is converted to UDP-glucose by UDP-galactose 4-epimerase [75].

Serotonin, known as 5-HT or hydroxytryptamine, is a biogenic monoamine acid type of neurotransmitter. Serotonin is a monoamine neurotransmitter that is synthesized in the central nervous system and enterochromaffin cells of the digestive system, and biochemically, it is a derivative of tryptophan. HT-5 receptors are involved in a number of diseases such as migraine, temporomandibular joint pain. Serotonin transporter (5-HTT) is the main regulator of HT-5 in the nervous system. 5-HTT can inhibit 5-HT in the synaptic cleft and thereby terminate serotonergic neurotransmission [13]. Previous studies have shown the role of 5-HT and 5-HTT in TMD patients [2]. The activity of galactose mutarotase gene was first reported in 1956. It seems that GALM may affect regional neurophysiology through changes in the serotonergic system and lead to disorders such as TMD [14]. One of the most important goals of the present study is to use this data after identifying the genetic risk factors involved in the development of the disease. The results obtained are more effective in the prevention and treatment of patients. Among the methods of prevention and treatment for TMD, it is possible to mention patient education and self-care, especially when it is done continuously. On the other hand, behavioral interventions such as reversing and changing habits using self-management instructions as It is considered a conservative, cheap and effective method for treating TMD patients [15]. Such treatments can be considered as a preventive solution in society, especially those who have disease-prone polymorphisms, if proven. The logic of choosing these behavioral treatments comes from the idea that parafunctional activities and socio-psychological factors play an important role in causing musculoskeletal pain. The goal of education is to reassure the patient, explain the nature of parafunction, etiology, prognosis of the problem, and reduce repetitive muscle tension and control the amount of muscle activity. Patients should be aware that parafunction habits do not change by themselves and that the patient himself is responsible for changing these behaviors. For this reason, it is important to encourage patients to practice and repeat what they should do at home and during daily activities, and to encourage and help them with tangible feedback. Since in every race and society Unique polymorphisms are common and can be effective in the course of the disease and response to treatment in that population [15-18]. Our review of the background showed that this issue (investigation of the effects of GALM gene) in TMD patients has not been done in internal studies. Considering the importance of the subject and the lack of sufficient studies, this study was designed to investigate the effects of the GALM, T/A, rs4776783 polymorphism on jaw noise in TMD patients.

Materials and Methods

In this case-control study based on a pilot study, 101 patients with TMD were identified in order to investigate the effect of the rs4776783 polymorphism on the GALM gene in TMD patients referred to the Department of Oral and Maxillofacial Diseases. DC/TMD criteria were used to diagnose this disease. This version is the most complete version of diagnosis of complications that was presented and published in 2014. This criterion is a valid tool for diagnosing any type of pain associated with TMD and differential diagnosis of common TMD disorders. This tool provides a two-axis system for TMD diagnosis: axis one is 7 physical diagnoses and axis two is to examine mental status and pain associated with disability. Then, the relationship between galactose mutarotase gene polymorphism and jaw noise in patients with temporomandibular disorders will be investigated. In order to perform the test, 5 cc of blood will be taken from the patient and will be poured into tubes containing the anticoagulant EDTA and will be sent to the genetics laboratory for further procedures.

Results

In this study, in order to investigate the effect of rs 4776783 polymorphism in the GALM gene on the occurrence of temporomandibular joint disorders (TMD) during the initial examination, 108 patients were included in the study and among them 7 patients had underlying diseases such as diabetes and vertebral deformity. Neck pain and history of maxillofacial cosmetic surgery were excluded from the study and finally 101 patients were included in the study. 103 people were examined in terms of not suffering from underlying diseases and not having TMD problems, and all 103 people were included in the study as healthy people. And finally, these two groups were evaluated genetically.

Genetic analysis:

5-1) Comparison of GALM gene polymorphism in patients with or without TMD.

101 patients with TMD along with 103 healthy individuals without a history of TMD were evaluated to investigate rs4776783 polymorphism in GALM gene. In Table 2 and Figure 1, the polymorphisms of the mentioned people have been examined.

5-2) The condition of TMD patients with or without jaw sound.

101 patients with TMD were evaluated with the mentioned questionnaires in the third chapter. The average age of the patients was 35.92 (±8.92). 21 of them were men and 80 were women. According to the questionnaire, 61 people felt the sound in their jaw while moving. On the other hand, according to the TMD/DC criterion, the number of people who have crepitus in the right and left jaws is equal.

In some cases, patients reported clicking and crepitus simultaneously. The overlap of the report of "the presence of sound in jaw movement" (based on the questionnaire) and the presence of clicks or crepitus in the TMD/DC criterion is shown in Table 4. In total, according to the questionnaire, 61 patients and according to TMD/DC criteria, 73 patients had jaw voice. The zygosity and genotypic status of patients with clicks and crepitus is shown in Table 5, which is significantly more common in heterozygotes. The age and gender distribution of patients is shown in Table 6, which shows the higher prevalence of clicks or crepitations in women and indicates that jaw disorders do not have a significant relationship with people's age.

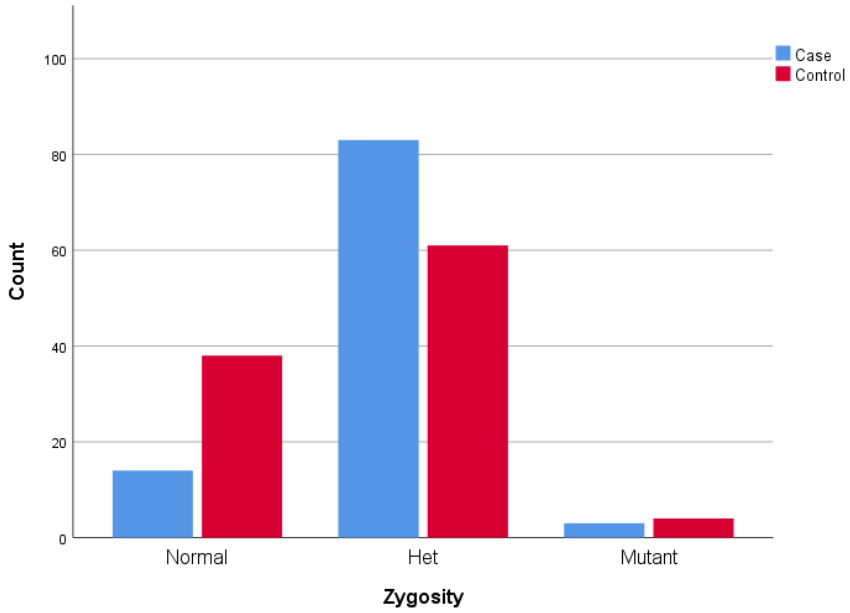
According to the above table, the frequency of A and T alleles in people who have clicking or crepitation according to the TMD/DC questionnaire is 52.1% and 47.9%, respectively. Also, this frequency is equal to 52.5 and 47.5% in people who report sound in their jaw. The low prevalence of crepitation with p=0.734 has a significant relationship with the genotype of people. In general, the odds ratio of clicking or crepitation based on the TMD/DC questionnaire for people with the abnormal polymorphism of rs4776783 in the GALM gene was 4.63, and this ratio was 2.32 for reporting the presence of sound in jaw movement. The comparison of genotypic status of people with clicking or crepitation in the jaw can be seen in picture 2.

Table 2. Comparison of rs4776783 polymorphism status in GALM gene in patients with history of TMD and control group.

p-value	*Control Group (n=103)*	*Patient TMD (n=101)*	*Variables1*	
0.001	*38*	*15*	*Normal*	*Zygocity*
	61	*83*	*Heterozygote*	
	4	*3*	*Mutant*	
0.001	*38*	*15*	*AA*	*Genotype*
	61	*83*	*TA*	
	4	*3*	*TT*	

a. Chi-square test

According to the above table, the frequency of A and T alleles in the entire population is 67.5% and 32.5%, respectively. This frequency in patients with TMD is equal to 55.5 and 45.5%, which is significantly higher than the general population.



Picture 1. GALM gene zygosity status in rs4776783 polymorphism in patients and control group.

Table 3. Status of clicking and crepitus in the right and left jaws of patients based on TMD/DC criteria.

Number of positive cases	*Status*	*Number of positive cases*	*Status*
52	*Clicking in left jaw*	*49*	*Clicking in Right jaw*
8	*Crepitus in left jaw*	*8*	*Crepitus in Right jaw*
60	*Total in the left*	*57*	*Total in the right*

Table 4. Overlap of the report of the presence of sound in jaw movement (based on the questionnaire) and the presence of clicking or crepitus based on the TMD/DC criterion.

Existence of sound in jaw movement			
No	*Yes*		
13	*60*	*Yes*	*TMD/DC criteria*
27	*1*	*NO*	

Table 5. Zygosity status of TMD patients with jaw voice.

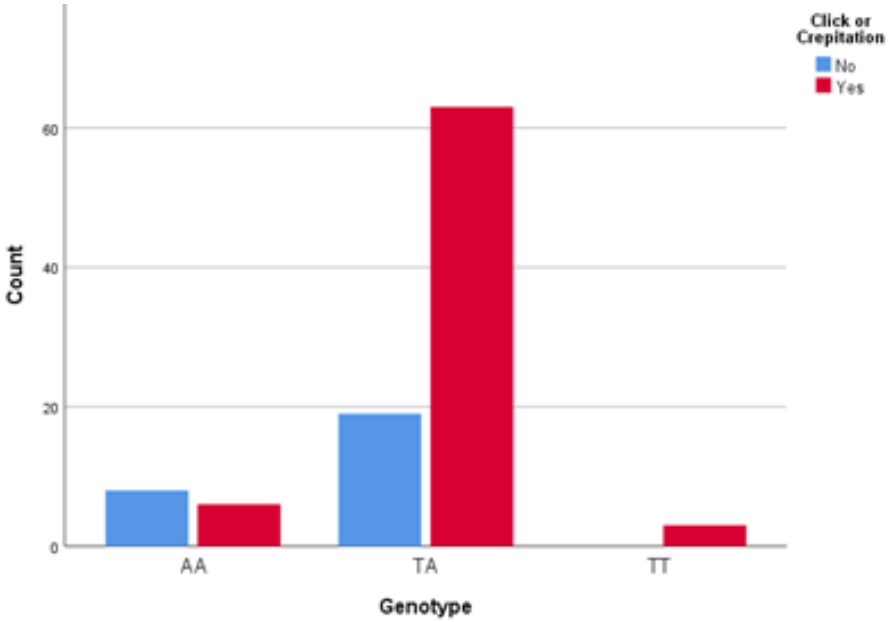
p-value	*Mutant*	*Zygocity* *Heterozygous*	*Normal*	*Disease status*
0.022	*3*	*57*	*5*	*Existence of Clicking (n=65)*
0.734	*0*	*8*	*2*	*Existence of Crepitus (n=10)*
0.0177	*3*	*65*	*7*	*Clicking or Crepitus (n=75)*

Table 6. Age and gender distribution of patients included in the study.

Sound in the jaw			*(TMD/DC) Clicking or Crepitus*			*Variables*
p-value	*No*	*Yes*	*p-value*	*No*	*Yes*	
0.327	*37±(9.33)*	*35.21±(8.65)*	*0.273*	*37.5±(9.01)*	*35.31±(8.87)*	*age*
0.541	*male :8 (20)٪ female: 33(80)٪.*	*male: 13(21.3)٪. female :48 (79.7)٪.*	*0.560*	*male :6 (21.4)٪. female : 22(78.6)٪.*	*male :15 (20.5)٪. female :58 (79.5)٪.*	*Gender*

Table 7. Genotype status of TMD patients with jaw voice.

p-value	*Genotype*			*Disease status*
	TT	*TA*	*AA*	
0.022	*3*	*57*	*5*	*Existence of Clicking (n=65)*
0.734	*0*	*8*	*2*	*Existence of Crepitus (n=10)*
0.0177	*3*	*65*	*7*	*Clicking Crepitus or (n=75)*



Picture 2. Genotypic distribution in TMD patients with or without clicking and crepitation in the jaw.

Discussion

For the first time, the American Association of Oral Pain (AAOP) proposed the role of genetic factors in the occurrence of TMD. It is assumed that a complex disorder such as TMD is multidimensional and can be affected by environmental conditions and several gene polymorphisms. Rather than being a rare and single mutation, genetic factors appear in the form of gene polymorphisms that are more common, therefore, the identification of single nucleotide polymorphisms in the human genome can play an important role in clinical foundations for diagnosis and determination. Prognosis and therapeutic interventions play a role in various diseases, including TMD [2-4]. TMD is one of the three most common chronic pains after headache and back pain, and this term scientifically includes a number of clinical problems that involve chewing muscles called Myofascial Pain Disorders (MPDs).

Among the common signs and symptoms of TMD are pain in one or both joints, limitation of opening the mouth, limitation of lateral movements and forward movement of the mandible, clicking sound, facial

deformities, headache, tinnitus, ear pain, and a feeling of ear fullness [26]. Serotonin, known as 5-HT or hydroxytryptamine, is a biogenic monoamine acid type of neurotransmitter. Serotonin is a monoamine neurotransmitter that is synthesized in the central nervous system and enterochromaffin cells of the digestive system, and biochemically, it is a derivative of tryptophan. HT-5 receptors are involved in a number of diseases such as migraine, temporomandibular joint pain. Serotonin transporter (5-HTT) is the main regulator of HT-5 in the nervous system. 5-HTT can inhibit 5-HT in the synaptic cleft and thereby terminate serotonergic neurotransmission (13). Previous studies have shown the role of 5-HT and 5-HTT in patients with TMD [2]. It seems that GALM may lead to disorders such as TMD through changes in the serotonergic system while affecting regional neurophysiology [14].

Based on the results of the present study, gene polymorphism (GALM4776783) (rs) showed a significant relationship with TMD. Most of the studies have confirmed the role of genetics in TMD disorders. For example: R. de Souza Tesch and his colleagues in a case-control study investigated the possible relationship between polymorphisms in catechol-O-methyltransferase (COMT) and β2-adrenergic receptor (ADRB2) genes and temporomandibular disorders (TMD) and finally concluded that the genetic role in TMD disorders is colorful [15]. Aneiros-Guerrero and his colleagues also investigated the role of genetics in the occurrence of TMD in 2011, based on their conclusion that genetic polymorphisms are related to TMD syndrome [18]. Also, based on the results of this study, it was found that there is a significant relationship between the rs gene polymorphism (GALM4776783) and the sensation of sound in the form of a click or crack in the jaw during movement. rs in the HTT-5 gene and the occurrence of temporomandibular joint disorders, they confirmed that there is a significant relationship between the 4776783 rs polymorphism in the HTT-5 gene and the occurrence of TMD and temporal masticatory muscle pain, clicking and temporomandibular joint pain, and thus the genetic background confirmed this complication [69]. Based on the results of this study, it was found that jaw sounds such as clicking or crepitation are more common in women. This conclusion is consistent with a 2012 study by Bagis and colleagues who examined the prevalence of temporomandibular joint disorder (TMD) signs and symptoms and concluded that TMJ pain at rest, pain in the masseter muscle, clicking, grinding, and use Antidepressant drugs in women were significantly more than men, it is consistent [71]. Also, based on the results of this study, it was found that there is a significant relationship between rs gene polymorphism (GALM4776783) and pain in most masticatory muscles, as well as the temporal muscle tendon. This is consistent with the findings of most studies. For example In 2019, Brancher and his colleagues investigated the effects of HTT5 and COMT gene polymorphisms in a case-control study in 2019. They concluded that rs1042173 in the HTT5 gene is associated with painful TMD, and in general, HTT5 gene polymorphisms are associated with TMD in adults is. By reviewing all the studies that were discussed in this chapter, among the advantages of this research was the study on the Iranian population, which made the genetic pathway of GALM gene expression evaluated in patients with TMD. Also, all studies show the important role of heredity in TMD. Therefore, it is suggested that due to the multi-cause of TMD and the very important and influential role of genetics on it, other genes as well as different polymorphisms should be investigated, and by knowing their mechanism of action, ways to prevent the transfer of the relevant genes To the next generations or provide preventive methods in this field.

Conclusion

This study showed that between rs4776783 polymorphism in Galm gene and occurrence of temporomandibular disorders (TMD), sensation of jaw sound (click or cryptus or both), pain sensation in many masticatory muscles such as external trigoid and temporal as well as temporal muscle tendon and gender There is a significant relationship between people, so it seems that the total prevalence of TMD disorders is higher in women. Therefore, it can be concluded that TMD has a genetic basis.

Conflict of Interest

There is no conflict of interest to declare.

References

[1] Ogura I, Kaneda T, Mori S, Sakayanagi M, Kato M. Magnetic resonance characteristics of temporomandibular joint disc displacement in elderly patients. Dentomaxillofacial Radiology. 2012 Feb; 41(2):122-5.

[2] Manfredini D, Guarda-Nardini L, Winocur E, Piccotti F, Ahlberg J, Lobbezoo F. Research diagnostic criteria for temporomandibular disorders: a systematic review of axis I epidemiologic findings.

Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2011 Oct 1; 112(4):453-62.

[3] Murphy MK, MacBarb RF, Wong ME, Athanasiou KA. Temporomandibular joint disorders: a review of etiology, clinical management, and tissue engineering strategies. The International journal of oral & maxillofacial implants. 2013 Nov; 28(6):e393.

[4] Basat SO, Surmeli M, Demirel O, Ceran F, Saydam FA, Basaran K. Assessment of the relationship between clinicophysiologic and magnetic resonance imaging findings of the temporomandibular disorder patients. Journal of Craniofacial Surgery. 2016 Nov 1; 27(8):1946-50.

[5] Hirata FH, Guimarães AS, Oliveira JX, Moreira CR, Ferreira ET, Cavalcanti MG. Evaluation of TMJ articular eminence morphology and disc patterns in patients with disc displacement in MRI. Brazilian oral research. 2007; 21:265-71.

[6] Chalkoo AH, Bhat ZA, Maqbool A. MRI characteristics of disc displacement of temporomandibular disorders and its correlation with clinical findings in symptomatic and asymptomatic. population. 2017; 1(2):4-9.

[7] De Leeuw R, Klasser GD, editors. Orofacial pain: guidelines for assessment, diagnosis, and management. Hanover Park, IL: Quintessence Publishing Company, Incorporated; 2018.

[8] Hietaharju M, Kivimäki I, Heikkilä H, Näpänkangas R, Teerijoki-Oksa T, Tanner J, Kemppainen P, Tolvanen M, Suvinen T, Sipilä K. Comparison of Axis II psychosocial assessment methods of RDC/TMD and DC/TMD as part of DC/TMD-FIN phase II validation studies in tertiary care Finnish TMD pain patients. Journal of oral rehabilitation. 2021 Dec; 48(12):1295-306.

[9] Wu J, Huang Z, Chen Y, Chen Y, Pan Z, Gu Y. Temporomandibular disorders among medical students in China: prevalence, biological and psychological risk factors. BMC oral health. 2021 Dec; 21(1):1-8.

[10] Rantala M. Temporomandibular disorders and related psychosocial factors in non-patients: A survey and a clinical follow-up study based on the RDC/TMD.

[11] Meloto CB, Serrano PO, Ribeiro-DaSilva MC, Rizzatti-Barbosa CM. Genomics and the new perspectives for temporomandibular disorders. Archives of Oral Biology. 2011 Nov 1; 56(11):1181-91.

[12] Michelotti A, Liguori R, Toriello M, D'Antò V, Vitale D, Castaldo G, Sacchetti L. Catechol-O-methyltransferase (COMT) gene polymorphisms as risk factor in temporomandibular disorders patients from Southern Italy. The Clinical journal of pain. 2014 Feb 1; 30(2):129-33.

[13] Wright EF, North SL. Management and treatment of temporomandibular disorders: a clinical perspective. Journal of Manual & Manipulative Therapy. 2009 Dec 1; 17(4):247-54.

[14] Look JO, Schiffman EL, Truelove EL, Ahmad M. Reliability and validity of Axis I of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) with proposed revisions. Journal of oral rehabilitation. 2010 Oct; 37(10):744-59.

[15] Bashizade H, Goodarzpour D, Mofidi N. Correlation between eminence steepness and condyle disk movements in temporomandibular joints affected by internal derangements using magnetic resonance imaging. J Dent Med-Tehran Univ Med Sci. 2013 Jan 1; 25:251-9.

[16] Thoden JB, Timson DJ, Reece RJ, Holden HM. Molecular structure of human galactose mutarotase. Journal of Biological Chemistry. 2004 May 1; 279(22):23431-7.

[17] De Souza Tesch R, Bonato LL, Quinelato V, Casado PL, Vieira AR, Granjeiro JM, Góes C. Evaluation of genetic risk related to catechol-O-methyltransferase (COMT) and β2-adrenergic receptor (ADRB2) activity in different diagnostic subgroups of temporomandibular disorder in Brazilian patients. International journal of oral and maxillofacial surgery. 2020 Feb 1; 49(2):237-43.

[18] Brancher JA, Spada PP, Meger MN, Fatturri AL, Dalledone M, de Paiva Bertoli FM, Deeley K, Scariot R, Vieira AR, Küchler EC, de Souza JF. The association of genetic polymorphisms in serotonin transporter and catechol-O-methyltransferase on temporomandibular disorders and anxiety in adolescents. Journal of Oral Rehabilitation. 2019 Jul; 46(7):597-604.

[19] Melis M, Di Giosia M. The role of genetic factors

in the etiology of temporomandibular disorders: a review. CRANIO®. 2016; 34(1):51-67.

[20] Aneiros-Guerrero A, Lendinez AM, Palomares AR, Perez-Nevot B, Aguado L, Mayor-Olea A, Ruiz-Galdon M, Reyes-Engel A. Genetic polymorphisms in folate pathway enzymes, DRD4 and GSTM1 are related to temporomandibular disorder. BMC medical genetics. 2011 Dec; 12(1):1-9.

[21] Catanzariti, J.-F., T. Debuse, and B. Duquesnoy, Chronic neck pain and masticatory dysfunction. Joint Bone Spine, 2005. 72(6): p. 515-519.

[22]Bagis B, Ayaz EA, Turgut S, Durkan R, Özcan M. Gender difference in prevalence of signs and symptoms of temporomandibular joint disorders: a retrospective study on 243 consecutive patients. International journal of medical sciences. 2012; 9(7):539.

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