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ORIGINAL ARTICLES

Masticatory laterality: parameter for evaluating TMD

[1]Yaser M. Alkhiary, [2]Mohammed M. El-Zawahry, [3]Amal H. Moubarak

[1]Prosthodontic Department, Faculty of Dentistry, King Abdulaziz University, (KSA).
[2]Prosthodontic Department ,National Research Center, Cairo, Egypt.
[3]Prosthodontic Department, Faculty of Dentistry, King Abdulaziz University, (KSA).

ABSTRACT

To date, masticatory laterality has not been fully examined as a parameter for evaluating tempro-mandibular disorders (TMD).This cross-sectional study included160 fully dentate dental professionals (mean 27 years old). Masticatory laterality was evaluated by using the observed preferred chewing side test. Muscle pain, tempro-mandibular joint (TMJ) pain, clicking, ranges of vertical and lateral mouth opening and deviation during mouth opening were also evaluated. Chi-square tests were used for statistical analyses; $p \leq 0.05$ was considered significant. The prevalence of masticatory laterality among the study participants was 60%; 86.5% of the participants with masticatory laterality chewed on the right side. Forty percent of the participants chewed bilaterally. Of the symptoms evaluated, deviation was the most common symptom among participants with TMD and masticatory laterality (69.1% -65.5%), followed by clicking (66.1% of participants with TMD and62.5% of those with masticatory laterality).Deviation was associated with TMD and masticatory laterality; no association was found between clicking and TMD or masticatory laterality. Seventy-two percent of participants with TMD chewed unilaterally and 28% chewed bilaterally Our results demonstrated a strong association between TMD and masticatory laterality, suggesting, within the limitations of this study, that people who have masticatory laterality may be more susceptible to TMD, especially unilateral TMD.

Key words: Temporomandibular disorders, masticatory laterality, unilateral chewing.

Introduction

Mastication is a combined voluntary and involuntary act. The decision to chew is voluntary, and as the masticatory act progresses, it becomes involuntary and dependent on complex peripheral and central neutral mechanisms (Christensen and Radue, 1985A).Mastication may occur bilaterally, but most people chew more on a particular side, which means that they have a preferred chewing side(PCS) (Christensen and Radue, 1985; Pond *et al.,* 1986; Kazazoglu *et al.,* 1994; Mioche *et al.,* 2002). Some studies have found no significant differences between the percentage of adults who prefer to chew on the left side and those who chew on the right (Christensen and Radue, 1985A; Pond *et al.,* 1986; Christensen and Radue, 1985B; McDonnell *et al.,* 2004). However, other studies have suggested that more adults prefer to chew on the right side (Varela *et al.,* 2003; Paphangkorakit *et al.,* 2006).

PCS has been investigated with various methods using a number of test foods. Some methods involve observing the bolus placement position in the oral cavity to determine the PCS (Christensen and Radue, 1985A; Kazazoglu *et al.,* 1994).Among test foods, chewing gum has been used most frequently (Christensen and Radue, 1985A; Kazazoglu *et al.,* 1994;McDonnell *et al.,* 2004; Varela *et al.,* 2003; Nissan *et al.,* 2004), although carrots (Pond *et al.,* 1986; Wilding and Lewin, 1991; Salioni *et al.,* 2005), almonds(Wilding, 1993),bread, toffee (Hidaka *et al.,* 1999), meat (Paphangkorakit *et al.,* 2006) and other foods have also been used (Paphangkorakit *et al.,* 2006; Shinagawa *et al.,* 2004; Mizumori *et al.,* 2003; Shiga *et al.,* 2003).

The factors that determine the PCS have not been identified (Minato *et al.,* 2009). It has been postulated that PCS is centrally determined and related to a preference for using the hand, eye, ear and foot on the same side (Nissan *et al.,* 2004). In contrast, other authors have suggested that preference for chewing on a particular side is related to peripheral factors (Pond *et al.,* 1986;Fantoni *et al.,* 2010). However, there is no agreement on whether peripheral factors such as occlusion (Wilding and Lewin, 1991; Salioni *et al.,* 2005; Hidaka *et al.,* 1999) or temporomandibular disorders (TMD) (Pond 1986; Tay, 1994; Reinhardt *et al.,* 2006; Egermark-Eriksson *et al.,* 1987; Casanova-Rosado *et al.,* 2006) influence the PCS.

In the year 348 BC, Hippocrates described a condition of the dislocation of temporomandibular articulation. Nonetheless, two millennia passed before a study was conducted to collect data on temporomandibulardisorder (TMD) or malfunction. The prevalence of this type of disorder, according to the literature, varies between 28

Corresponding Author: Yaser M. Alkhiary, Associate Professor, Prosthodontic Department, Faculty of Dentistry, King Abdulaziz University

and 88%, depending on the population studied as well as the diagnosis system used (Casanova-Rosado *et al.,* 2006; Shiau and Chang, 1992).

TMD has been described as a cluster of disorders characterized by pain in the preauric-ular area, temporomandibular joint (TMJ), or the masticatory muscles; limitation or deviations in the mandibular range of motion; and clicking in the TMJ during mandibular function. Such disorders are not related to growth or development disorders, systematic diseases, or macrotrauma (Casanova-Rosadao *et al.,* 2006; Carlsson and Magnusson, 1999).

A unilateral chewing pattern may be considered an expression of impaired function and has been shown to be associated with signs and symptoms of temporomandibular disorders (Reinhardt *et al.,* 2006; Miyake *et al.,* 2004; Tay *et al.,* 1989). Diernberger *et al.* (2008) have demonstrated a significant correlation between PCS and signs and symptoms of TMD, whereas others have not found a relation between PCS and TMD (Pond *et al.,* 1986; Jordi *et al.,* 2009). Therefore, the data regarding TMD as a causal factor on the expression of masticatory laterality is inconclusive.

Since the main factors determining the PCS are unknown, the objective of the present study was to determine whether TMDis related to masticatory lateralityin an adult population with a full complement of natural teeth.

Materials And Methods

Participants and study design:

Faculty members and students with natural dentition were invited to participate in this cross-sectional study. Those who decided to participate (n =160, 131 women and 29 men) received and signed a letter of informed consent. Their ages ranged from 19.8 to 47.9 with a median age of 22.2. Subjects with fewer than 24 natural teeth, those undergoing active orthodontic treatment, or those suffering orofacial pain from disorders other than TMD were excluded. The investigation was performed in accordance with the principles of the Helsinki Declaration.

Chewing side preference test:

The study subjects were informed that the aim of this study was the evaluation of mastication. Subjects were not aware that the PCS was the item of interest to avoid bias and awareness of chewing side. Subjects were instructed to sit on the dental chair in an upright position. Three penciled dots were marked on the subject's facial skin; one at the tip of the nose, one just below the center of the lower lip and one on the chin. The subjects were asked to move their head as little as they would during the recording session so that the three marked dots were aligned vertically during each chewing trial to help distinguish the path of chin movement (Paphangkorakit *et al.,* 2006).

The PCS was evaluated using a test described by Kazazoglu *et al*. (Kazazoglu *et al.,* 1994), which involves performing a visual inspection to determine the position of a piece of chewing gum after 1, 3, 5 and 7 consecutive chewing cycles. This test is more commonly known as Observed Preferred Chewing Side (OPCS). If the chewing gum was observed to be on the same side for three consecutive bites, the patient was considered to have a chewing side preference. After 2 minutes of mastication, each subject was questioned as to the position of the chewing gum, a procedure that is designed to ascertain what is commonly known as a 'State Preferred Chewing Side' or SPCS (Kazazoglu *et al.,* 1994;Varela *et al.,* 2003).

TMD clinical examinations:

Participants underwent clinical examination for the following symptoms commonly associated with TMD: TMJ tenderness, masticatory muscle tenderness, joint sounds such as clicking during opening and/or closing, deviation and limited vertical or lateral mouth opening (V-LMO and L-LMO, respectively).

Clinical examination was performed according to the following criteria (Carlsson and Magnusson, 1999; Kahn *et al.,* 1998; Bumann *et al.,* 2002):

Pain: Pain was determined by palpation of the joints and masticatory muscles with the mandible stationary and during function by a bilateral palpation technique (Watanabe *et al.,* 1998). The following sites were palpated extra-orally: lateral and posterior aspects of the TMJ, masseter, temporal muscle, and the insertion of medial pterygoid and sternocleidomastoid muscles. A positive score was assigned if a patient felt a distinctively tender or painful sensation in the site palpated. The sensation was carefully confirmed by repeatedly palpating the relevant sites.

Clicking sounds:"Clicking sounds" were defined as short, hard sounds in response to digital finger palpation bilaterally over the lateral aspects of the TMJs while the subjects were asked to make four wide

opening and four lateral jaw movements (Nassif *et al.,* 2003). TMJ clicking was categorized as clicking during opening or clicking during closing. Clicking of the TMJ, either unilateral or bilateral, was recorded.

Deviation: Deviation was defined as any shift of the jaw midline during opening, which may disappear by continued opening with a return to midline. The pathway of mandibular opening for each patient was recorded as follows: straight opening with no deviation, deviation to the right side, or deviation to the left side. A patient's tendency to deviate towards any side was regarded as a positive diagnostic sign.

Mouth openings: The participant was asked to open his/her mouth as wide as possible to measure maximal active mouth opening. Maximal passive mouth opening was measured after the application of downward pressure on the mandible by the second and third fingers of the participant. The vertical distance between the upper and lower teeth was measured with a ruler. The amount of vertical incisor overlap was added to each of these measurements to determine the actual amount of opening. The lateral jaw motion was assessed by measuring the horizontal distance between the midpoints of upper and lower incisors as the mandible moved as far as possible toward the right or left. Values less than 50mm for B-LMO and less than 8mm for L-LMO were considered symptomatic.

Grouping of the participants:

The symptomatic group consisted of individuals having two or more of the measured symptoms. If only one side was affected, the patient was considered to have unilateral-TMD(U-TMD). If both sides were affected, the patient was considered to have bilateral-TMD (B-TMD). Thus, three groups were represented: 'asymptomatic', 'symptomatic with U-TMD' or 'symptomatic with B-TMD'.

Statistical analysis:

Chi-squared tests and Fisher exact tests were used for non-parametric data, and the numerical data analyses were performed using one-way ANOVA. A P-value ≤0.05 was considered significant. All analyses were performed using R version 2.15.2 (R Foundation for Statistical Computing, http://www.r-project.org).

Results:

Masticatory laterality:

Distribution of chewing side preference:

Based on the aforementioned chewing laterality criteria, subjects had a PCS (8 preferred the right and 1 preferred the left) and 9 subjects were chewed bilaterally (Table 1 and Figure1)

Table 1: Distribution of chewing side preference.

Chewing side	N	%
Right	8	51.5%
Left	1	8.2%
Bilateral		%
Total	160	100%

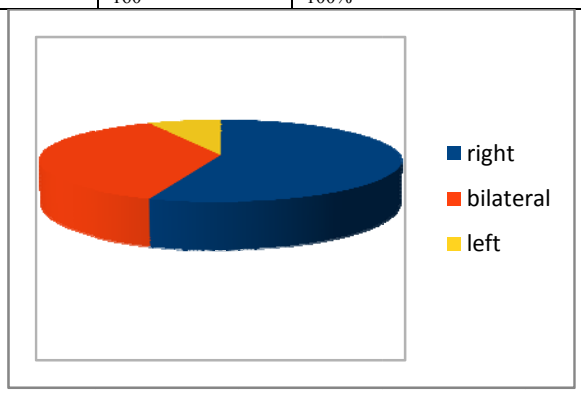

Fig. 1: Distribution of chewing side preference.

Relation of masticatory laterality and gender distribution:

Our results revealed no statistical difference in the distribution of males and females between unilateral or bilateral chewers (Table 2 and Figure2).

Table 2: Distribution of both genders in unilateral and bilateral chewers.

Variable	Unilateral chewers(n=96)		Bilateral chewers(n=64)		p- value
Gender	Female	Male	Female	Male	
N	82	14	49	15	0.22

N: number of participants

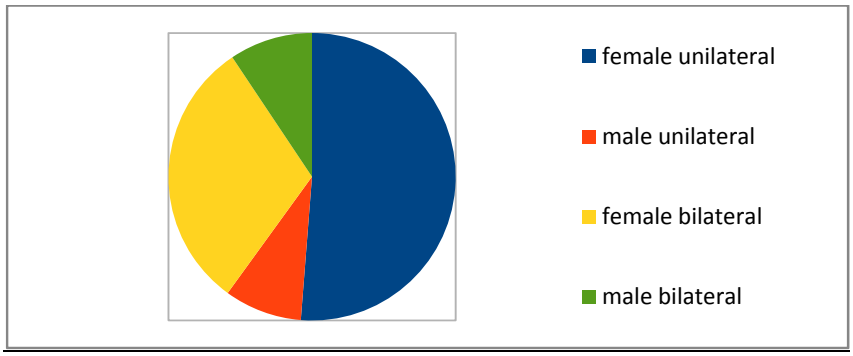

Fig. 2: Distribution of both genders in unilateral and bilateral chewers.

TMD:

Distribution of TMD and accompanied symptoms:

Of our participants, 42.5% were determined to have TMD. The most frequent symptom in the TMD group was 'deviation during opening' and was detected in47 (69.1%) of the study participants with TMD. Clicking sounds were detected in 45 (66.1%) of the participants with TMD, muscle pain was detected in 31 (45.5%), TMJ pain was detected in 30 (44.1%), and limited lateral and vertical mouth openings were detected in 15 (22.1%)and 7 (7.6%), respectively.Significance differences in muscle pain, deviation, TMJ pain and limited lateral mouth opening were detected between the TMD and non-TMD group. In contrast, no significant difference in clicking sounds was observed between TMD and non-TMD participants(Table 3 and Figure 3).

Table 3: Distribution participants with symptoms with respect to TMD.

Variable	TMD participants(n=68		Non-TMD participants(n=92		p value
	No.	%	No.	%	
Muscle pain	31	45.5	12	13	.001
Deviation	47	69.1	45	48.9	.001
TMJ pain	30	44.1	19	20.6	.002
Clicking sounds	45	66.1	50	54.3	.179
Limited vertical mouth opening	7	7.6	7	10.2	.756
Limited lateral mouth opening	15	22.1	5	5.4	.004

Relation of TMD and gender distribution:

Our results revealed that no statistical difference between distribution of males and females in the TMD and non-TMD group existed (Table 4 and Figure4).

Table 4: Comparison of the distribution of genders in the TMD and non-TMD group

Variable	TMD participants(n=68)		Non- TMD participants(n=92)		p value
Gender	Female	Male	Female	Male	
N	60	8	71	21	0.11

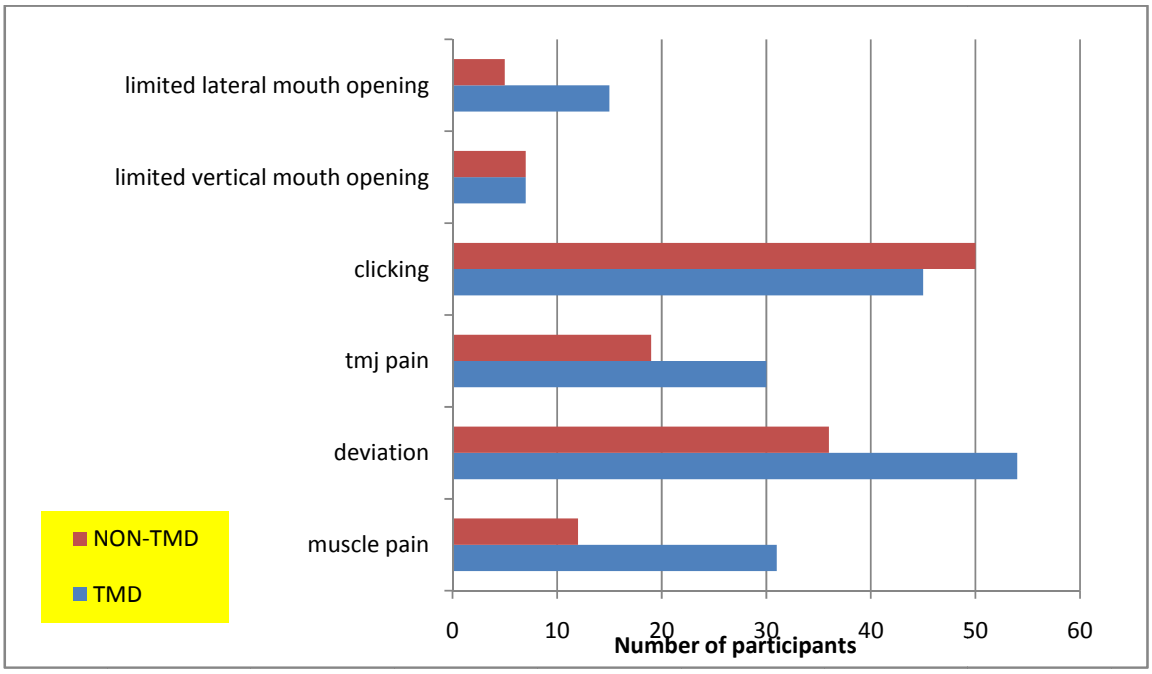

Fig. 3: Distribution of study participants with symptoms with respect to TMD.

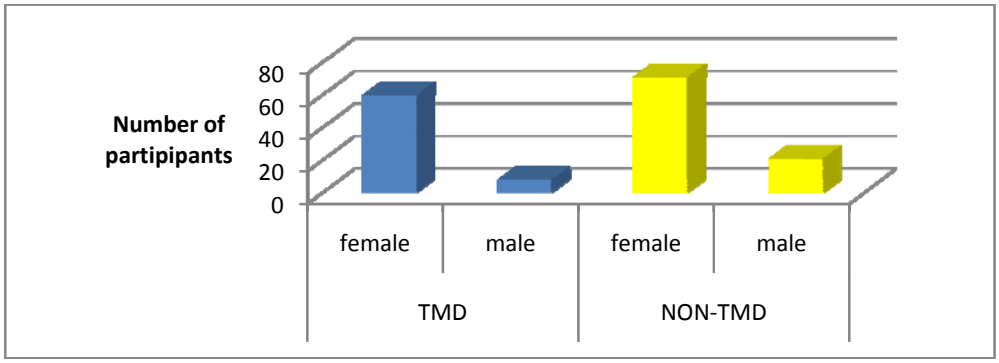

Fig. 4: Comparison of the distribution of genders in the TMD and non-TMD group

TMD symptoms and masticatory laterality:

Frequency of TMD symptoms in unilateral and bilateral chewers:

The most frequent symptom observed in unilateral chewers was deviation (65.5%), followed by clicking sounds(62.5%), muscle pain (34.3%) and TMJ pain (27.1%). There was a significant difference in the occurrence of muscle pain, deviation, and limited lateral mouth opening observed in the unilateral chewer group compared with the bilateral chewer groups (Table 5 and Figure5).

Table 5: Distribution of participants with symptoms with respect to masticatory laterality.

Variable	Unilateral chewers(n=96)		Bilateral chewers(n=64)		p value
	No.	%	No.	%	
Muscle pain	33	34.3	10	15.5	.015
Deviation	63	65.5	27	41.1	.002
TMJ pain	26	27.1	12	18.7	.306
Clicking sounds	60	62.5	35	54.6	.411
Limited vertical mouth opening	12	12.5	2	3.1	.077
Limited lateral mouth opening	20	20.8	0	0	.001

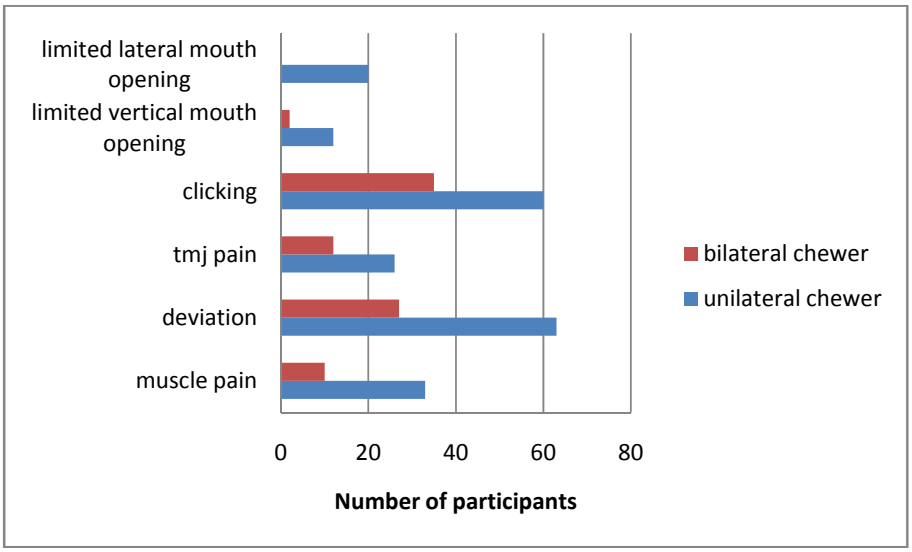

Fig. 5: Distribution of participants with symptoms with respect to masticatory laterality.

Relation of masticatory laterality and TMD:

Among the TMD study participants, 72% chewed unilaterally and 28% chewed bilaterally. In contrast, there was a nearly equal distribution of unilateral and bilateral chewers among the non-TMD participants. In addition, our results revealed that there was significant difference in the distribution of masticatory laterality between TMD and non-TMD participants (Table 6 and Figure 6).

Table 6: Distribution of masticatory laterality among TMD and non-TMD patients

Variable	TMD participants(n=68)		Non-TMD participants(n=92)		p value
	No.	%	No.	%	0.01
Unilateral chewer	49	72	47	51	
Bilateral chewer	19	28	45	49	

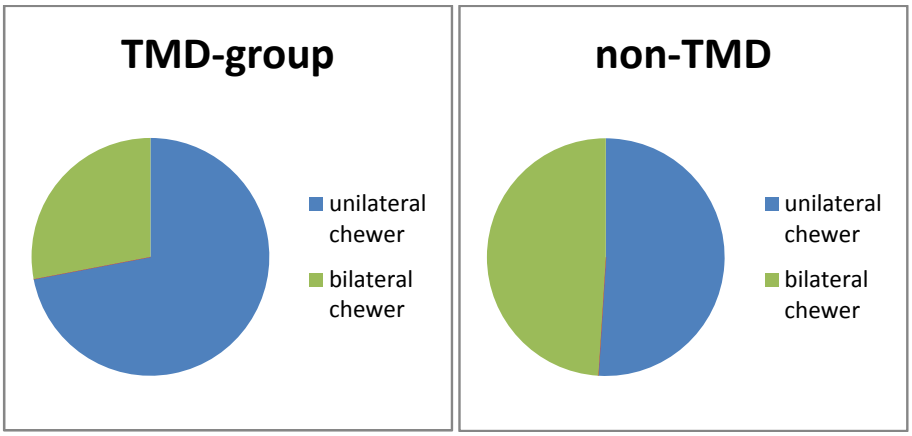

Fig. 6: Distribution of masticatory laterality among TMD and non-TMD patients

Among unilateral chewers, 49% were free from TMD, 19.7% had bilateral TMD and 31.3% had unilateral TMD. Of the bilateral chewers, 70.3% were free from TMD,3.1% had bilateral TMD and 26.6% had unilateral TMD. There was a significance difference in the distribution of participants with no TMD, bilateral and unilateral TMD between the unilateral and bilateral chewers(Table 7 and Figure7).

Table 7: Distribution of TMD among unilateral and bilateral chewers

Unilateral chewers			Bilateral chewers			p-value
Non-TMD	Bilateral-TMD	Unilateral -TMD	Non-TMD	Bilateral-TMD	Unilateral -TMD	0.003
47	19	30	45	2	17	
49%	19.7%	31.3%	70.3%	3.1%	26.6%	

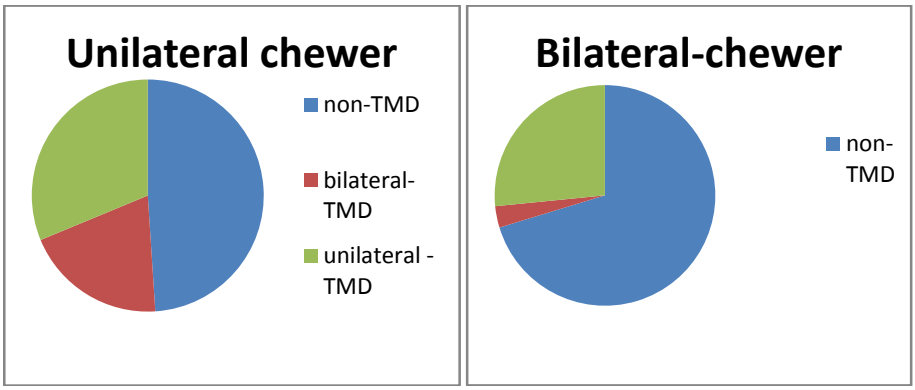

Fig. 7: Distribution of TMD among unilateral and bilateral chewers

Discussion:

Masticatory laterality:

Mastication is not performed equally on both sides of the dentition; instead, unilateral chewing occurs in about 70% of consecutive chewing cycles (Minato *et al.,* 2009; Casanova-Rosado *et al.,* 2006).Many authors have found that human subjects have a favored chewing side (Christensen and Radue, 1985B; Komagamine *et al.,* 2011).The results of the present study, which showed that 63% of the participants were unilateral chewers and 37% were bilateral chewers, are consistent with these previously reported studies. The commonly reported marked preference of chewing on the right side (Nissan *et al.,* 2004; Paphangkorakit *et al.,* 2006; Salioni *et al.,* 2005; Diernberger *et al.,* 2008; Delport *et al.,* 1983; Hoogmartens *et al.,* 1987)was confirmed by our findings .Delport *et al*. (1983)suggested that the preference for chewing on the right side is a result of having a central control neuromuscular mechanism.

To our knowledge, the effect of gender on masticatory laterality has not been clearly addressed in the literature. Our results revealed that there was no statistical difference in the distribution of chewing side preference between genders. The non-significant distribution of chewing side preference according to gender might be related to close similarity in life style between both genders in this study. The difference between males and females may be minor if the social roles are the same, whereas in a male-dominant society, the differences may become significant (Shiua and Chang, 1992; Miyake *et al.,* 2004).

TMD:

TMD is an extremely common disorder that is most often reported in individuals between the ages of 20 and 40 (Bilt, 2011).In our study, 42.5% of the participants were determined to have TMD. Casanova-Rosado *et al*. (2006)found a TMD prevalence of 46.9% and Shiau and Chang (1992)reported a prevalence of 42.9% among university students. These findings are similar to those reported in numerous other studies (Casanova-Rosado *et al.,* 2006; Carlsson and Magnusson, 1999; Nassif *et al.,* 2003).It may seem surprising to find such a high prevalence of TMD in an elite group of able-bodied young dentists. TMD has been reported to range from 15 to 25% to as high as 80% in a given population (Nassif *et al.,* 2003; Al-Jabrah and Al-Shumailan, 2006; Pedroni *et al*, 2003). According to Clark *et al*. (1993), the variations in frequency may be due to the fact that the term TMD is very ambiguous and unrestrictive.

The most common symptom in the TMD group was deviation during opening(found in 69.1% of the participants), followed by clicking sounds(found in 66.1%). Joint sounds are very common among patients with TMD and in non-patient populations, as reported in many previous studies (Bumann *et al.,* 2002; Al-Jabrah and Al-Shumailan, 2006; Könönen *et al.,* 1996). The frequency of TMJ sounds in epidemiologic studies varies from 3% to 60% (Bumann *et al.,* 2002).Carlsson and Magnussam (1999) reported that there is no data to substantiate the theory that joint sounds predispose one to pain or functional limitations in the long term. They also argued that most TMJ sounds are not pathological and may be deemed acceptable variations of anatomical normalcy or due to muscular in-coordination because it is very common to find joint sounds without the presence of any other signs or symptoms of TMD. These findings may explain why we found no association between clicking and TMD.

Myalgia associated with TMD is described as an aching pain localized to the masticatory muscles that worsens upon muscle palpation and increases with function. Somewhere between 50% and 70% of all patients

with TMD report masticatory muscle pain, and in 25% of these patients, pain in the masticatory muscles is the principal source of pain. Muscle pain may result from excessive reflex tone in the jaw muscles. The 'vicious cycle theory' of masticatory muscle pain proposes that an initial increase in muscle tone results in jaw muscle pain, which further increases muscle tone, resulting in muscle spasm and/or fatigue that increases pain in a cyclic, reinforcing manner (Cairns, 2010; Murray and Peck, 2007).Our findings demonstrated that muscle tenderness and TMJ pain occurred in 45.5% and 44.1% of the study participants with TMD, respectively. Our data also indicated that muscle tenderness and TMJ pain were more likely to occur in individuals with TMD than in those without the disorder.

In the present study, only 22.1% of the study participants with TMD had limited mouth opening in the lateral movement. Although other symptoms were more prevalent in participants with TMD, 22.1% was similar to the results reported by Akhter *et al*. (2011) and Nassif *et al*. (2003). Speculative reasoning is that limited lateral mouth opening represents a change in the muscular contraction pattern that acts as a trigger mechanism provoking disorders of the stomatognathic system. This reason might support the 'pain adaptation model', which proposes that pain results in alterations of muscle activity, which then limit movement to protect the jaw from further damage and promote healing (Cairns, 2010; Murray and Peck, 2007).No significant difference in the occurrence of limited mouth opening in the vertical direction was found between participants with TMD and those without; this finding was similar to those ofde Felício *et al*. (2007).

A number of studies such as those performed by Helkimo (1974)and Santana-Mora *et al*. (2009)have demonstrated that signs and symptoms of TMD are present in both sexes in equal proportions. We documented a similar tendency as we have demonstrated that neither gender has a greater percentage of problems relating to TMD .In contrast, studies by Koidis *et al*. (1993) and Shiau and Chang (1992)have reported a higher prevalence of TMD pain in women than in men. Although attempts have been made to provide an explanation for this difference, such as the proposal by Parker (1990)that suggested that the difference is due to the structural differences between men and women in the components of articulation, more studies are needed to determine if gender difference in the prevalence of TMD exists.

TMD and masticatory laterality:

Unilateral chewing can be used as an independent predictor of TMD as we found that subjects who chew unilaterally have higher rates of TMD 72% than those who chew bilaterally 28%. In this study, an association between unilateral chewing and TMD was demonstrated ($p = 0.01$). Signs and symptoms of TMD have been reported to be associated with a PCS (Wilding and Lewin, 1991; Egermark-Eriksson *et al.,* 1987; Casanova-Rosado *et al.,* 2006; Diernberger *et al.,* 2008).In addition, Miyake *et al*. (Miyake *et al.,* 2004) demonstrated that chewing on one side is associated with an increased risk of TMJ pain and impaired mouth opening. The probable cause of this association might be the continuous muscle hyperfunction and hyperactivity followed by myospasm that induces other dysfunction symptoms (Al Hadi, 1993).Increased muscle activity on the chewing side can be deduced from studies showing higher EMG levels for the masseter muscle on the chewing side than on the non-chewing side (Kumai, 1993). Multiple logistic regression models have demonstrated that chewing on one side causes an increased risk of TMJ pain. Pond *et al*. (1986) found that preference for a side was associated with some asymmetric factors of the orofacial system, such as unilateral pain in facial muscles or the TMJ or subjective unilateral joint clicking. Tay *et al*. (1989) suggested that subjects with severe TMD tend to divert chewing to one side. Ratnasari *et al*. (2011) ound a significant predominance of the PCS on the ipsilateral side of anterior disc displacement during mastication of hard food. These patterns of characteristic movements seem to be adaptive responses that allow chewing to occur with the least amount of pain and damage.

Although the alterations observed in the chewing patterns of patients with TMD are probably direct consequences of TMD and/or muscular disorders, this does not eliminate the possibility that chronic unilateral chewing during developmental stages and childhood could predispose an individual to certain articular-intracapsular dysfunctions as well as internal degeneration. Therefore, it is possible that unilateral chewing is a causal factor in the development of TMD (Casanova-Rosado *et al.,* 2006). Masticatory laterality was found associated with signs of TMD in just over half of the study group(51%).Thus, unilateral masticatory pattern may be an expression of impaired function and may also be associated with signs and symptoms of TMD.

Individuals with a predominant chewing side were more likely to have unilateral TMD(31.3%)than bilateral TMD (19.7%). One would expect that the disorder will be on the contralateral joint from the side that the patient chews on. The occurrence of pain in the non-chewing side joint may be explained by the increased loading of this joint as a consequence of chewing on the other side. The balancing joint is more loaded during function than the working one ,and exclusively unilateral mastication can change the structure of the condylar cartilage (Diernberger *et al.,* 2008; Palla *et al.,* 2003). One study predicted TMJ loading using biomechanics models (Korioth and Hannam, 1994). A static mathematical simulation model of uni-lateral molar clenching demonstrated that joint forces are greater on the contralateral side. The study by Tay *et al*. (1989) found that patients with anamnestical unilateral facial muscle pain showed a significant chewing side preference compared

with patients with no or bilateral symptoms. Unfortunately, in our study, we did not relate an obvious pattern for the localized symptoms in the joint of chewing with the joint of pain or the disorder.

It has been reported that chewing performance is more stable on the PCS than the non-PCS (Wilding and Lewin, 1991; Minato *et al.,* 2009). With regard to bite force, the unilateral maximum bite force on the PCS is greater than that on the non-PCS (Fantoni *et al.,* 2010). Moreover, the chewing cycle is more regular and rapid on the PCS (Wilding, 1993). Therefore, it would be necessary to study other criteria of chewing in terms of time, force, movement, performance, and number of strokes to fully understand mastication and its possible limitation in patients who chew unilaterally.

Conclusion:

Within the limitations of this study, the data suggested that people with masticatory laterality may be more susceptible to TMD and are more likely to have unilateral TMD. Deviation during mouth opening was the symptom most closely associated with TMD and the choice of a PCS. This study is a cross-sectional study; future longitudinal studies would be expected to clarify the actual cause-and-effect relationship between these phenomena.

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