The evaluation of the reduction of symptoms of TMJ disorders by occlusal splint adjusted at vertical dimension of rest registered by two methods: A comparative study

Manal R. Alammari[1]*, Eman M. Al-Rafah[2], Yaser M. Alkhiary[3]

[1]Assistant Professor and [3]Associate Professor in Prosthodontics, Department of Oral and Maxillofacial Rehabilitation, Division of Removable Prosthodontics, King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia

[2]Professor in Prosthodontics, Department of Oral and Maxillofacial Rehabilitation, Division of Removable Prosthodontics, King Abdulaziz University - KSA. Alexandria University, Egypt

***Corresponding author:**
M.R Alammari.
Dept. of Oral and Maxillofacial Rehabilitation, King Abdulaziz University
Dental Hospital. Kingdom of Saudi Arabia
Tel: +966 (2)6403443 Ext: 23273
Fax: +966(2)6403316
P.O.Box 80209
Jeddah 21589, Western Region. Saudi Arabia
Email: malammari@kau.edu.sa

Abstract

Bruxism can cause signs and symptoms of temperomandibular disorders (TMD). Moreover, it will affect structures of the masticatory system. The most commonly established treatment approach for both bruxism and TMD is conservative and reversible management which include often occlusal devices (splints). Following ethical approval, 16 Male dental patients, with signs and symptoms of TMD due to bruxism were enrolled. Patients were randomly divided into two groups, eight patients in each according to the fabrication of the stabilization splint at occlusal opening of rest position of the mandible. Primary impressions were made, poured to form study casts upon which special trays were fabricated. Then, final impressions and master casts were made on which a full arch mandibular plane occlusal splint (stabilization type) in heat cured acrylic was made over the occlusal and incisal surface of the teeth. In group one, splint thickness (ST) made according to the height of rest vertical dimension (VDR) registered by using divine proportion method. While in group two, ST made according to the height of rest vertical dimension registered by conventional method. For all the patients, the index for clinical dysfunction of masticatory system validated by Helkimo was obtained to determine the degree of TMD. In patients with signs and symptoms of TMD syndrome and bruxism, a plane occlusal splint (stabilization splint) with occlusal opening up to the VDR produces relief of symptoms. The divine proportion method gives consistent measurement and

should be considered a reliable method for determination of VDR especially in TMD persons.

Keywords: bruxism, divine proportion ratio, temporomandibular joint disorders (TMD), VDR, occlusal splint.

{**Citation:** Manal R Alammari, Eman M Al-Rafah, Yaser M Alkhiary. The evaluation of the reduction of symptoms of TMJ disorders by occlusal splint adjusted at vertical dimension of rest registered by two methods: A comparative study. American Journal of Research Communication, 2013, 1(3): 1-17} www.usa-journals.com, ISSN: 2325-4076.

Introduction

Bruxism is widely defined as an anxiety response to environmental stress. It can cause signs and symptoms of temporomandibular disorders (TMD), as well as adjacent structures of the masticatory system, excessive teeth wearing (1-3), pain in the temporomandibular joints (4,5), masticatory muscles, and/or headaches are common findings (6).

The association between temporomandibular disorders (TMD) and bruxism has often observed in the literature (7-9). In a series of 86 patients with bruxism, researchers found that 89.6% to have symptoms of TMD (10). Sjoholm, Polo and Alihanka (11) in turn recorded joint and muscle tenderness in almost half of their bruxing patients, with a 25% incidence of headache and joint clicking. According to some authors, bruxism contributes to the development of TMD (12, 13). However, others have observed no such association between bruxism and TMD (14,15).

The most widely accepted treatment approach for both bruxism and TMD is conservative and reversible management including occlusal devices (splints), behavioral techniques, and pharmacological and physical procedures-the indicated therapeutic combination depending on the particular symptoms involved and/or the predominant influence of one etiological factor or other (1,6,9,11).

In the case of bruxism, it may be considered that while no conservative treatment modality is superior to any other, the occlusal splint is the most widely used option. The manifestation of TMD are markedly improved by these devices, even when the bruxing

habit persists (1,6,9,11,12). Full arch maxillary stabilization splints are often used in the management of craniomandibular disorders (6,13-18). They provide a good tool for the elimination of occlusal interferences to reduce neuromuscular activity and to obtain stable occlusal relationships with uniform tooth contacts throughout the dental arch.

Studies on the effects of stabilization splints on the neuromuscular system in patients with functional disorders indicate that the splints reestablish symmetric and reduced postural activity in the temporal and masseter muscles and significantly reduce the masseter muscle activity during maximum clenching.(14,19,20). Roura and Clayton in1975 found that after 1 month of occlusal splint therapy in patients with temporomandibular joint dysfunction, there was relief of most of the clinical symptoms and reduction of postural activity in the elevator muscles (21).

The divine proportion -also known as the golden proportion-was developed by Greek mathematicians and states that the length of a line is divided into two parts such that the sum of the minor part divided by the major part equals the major part divided by the total length In other words,the major part is 1.61803 times as long as the minor part (22-24).

The divine golden proportion has various dental applications especially in dental esthetics and several studies examined the relationship between the mesiodistal widths of maxillary anteriors in terms of golden proportion (25-27). These concluded that although the advocated golden proportion ratios are not found in nature, they do provide esthetically pleasing results.

Shoemaker etal(28) designed a patented clinical tool, the golden link caliper (GLC) which is a divider-caliper type instrumentation based on the golden proportion of 1 to 0.618 wherein the instrument is particularly adapted for utilization in a wide variety of dental procedures and is especially useful for clinically relating tooth size to existing anatomic form. They stated that this caliper can be useful also in Locating the vertical position of both Maxillary and Mandibular central incisors.

Soliman tested the use of divine proportion method versus phonetics and physiologic methods in determination of vertical dimension at rest (VDR) on twenty completely

edentulous patients. She found that the difference between the VDR determined by conventional methods and divine proportion method were significant. She concluded that the divine proportion method should be considered as a method of determination of VDR (29). The amount of the occlusal opening of the occlusal splint required to produce the desired relief of TMD symptoms has not been specifically defined. It has been suggested that the occlusal splint opening should not exceed the postural or rest position of the mandible (13)

This study will evaluate the influence of the vertical dimension in the reduction of the symptoms of TMD by means of stabilization splints (SS) fabricated at occlusal opening of rest position of the mandible registered by divine proportion method (novel method) versus conventional swallowing threshold method.

Material and methods

Following ethical approval, that was granted by Ethical Committee at King Abdulaziz University. 16 Saudi male subjects attending a dental Prosthodontics clinic, faculty of dentistry, King Abdulaziz University were enrolled. Their age ranged from 35-50 years old with signs and symptoms of Temporomandibular joint disorders (TMD) due to bruxism. All of them had two or more TMD signs/symptoms identified by two experienced dentists. Patients who had previously used an occlusal splint, or showed radiographic changes of TMJ, or used removable prosthesis were excluded. Each subject gave hers/his written informed consent for participating in this investigation.

For all subjects, maxillary and mandibular primary impressions were made using a reversible hydrocolloid impression material (Aromafine DF III alginate, Japan) in modified stock trays. These impressions were poured in plaster to form study casts upon which special trays were fabricated in auto-polymerizing acrylic resin (Ostron 100, Japan) and final impressions were recorded using polyvinyl silicosan impression material.

The final impression were poured in dental stone and mounted on a semi-adjustable articulator (Hanau^{TM} wide-vue, Water Pik Technologies, Inc, Fort Collins, Colo) by

using an ear piece face-bow (Hanau; Water Pik Technologies Inc) and centric relation record. A full arch mandibular plane occlusal splint (stabilization type) in heat cured acrylic (Acrostone, heat cure transparent, England, UK) was made for each patient over the occlusal and incisal surface of the teeth.

Figure 1: A full arch mandibular plane occlusal splint (stabilization type).

The splint was adjusted with the patient in supine position to provide a stable plane occlusion in retruded contact position as well as habitual closure, with a possibility of smooth gliding in lateral and protrusive excursions. The patients were instructed to wear the stabilization splint 3 hours daily and continuously at night for three months.

Patients were instructed not to take any medications such as tranquilizers or muscle relaxants during the period of splint therapy. Moreover, they had been asked not to take any sedative drugs during the day of clinical examinations.

The patients were randomly divided into two equal groups, eight patients each according to the fabrication of the stabilization splint at occlusal opening of rest position of the mandible registered by divine proportion method versus conventional swallowing threshold method.

Group I includes eight patients with splint thickness made according to the height of rest vertical dimension (VDR) registered by using the divine proportion method where the patients were asked to relax while sitting in a comfortable upright position without supporting the back or head rest. The VDR was measured by the le divine mean caliper (Le divine mean clipper, UK), where the gauge upper two bows are being opened for a specific measurement then it automatically opens the third bow.

The upper first bow will point to the inner canthsus of the eye, the second bow points to the ala of the nose and automatically the third bow will open to reach the base of the chin (menton) (1:1.618) (fig 2).

Figure 2: The VDR was measured by the le divine mean caliper.

The resulted measurements of VDR were recorded by measuring the distance between two points along the midline of the face using Boley's gauge in mm. The thickness of the splint was made according to the height of the vertical dimension at rest registered by the Le divine caliper.

In group II, eight patients with splint thickness made according to the height of rest vertical dimension registered by a conventional method (swallowing threshold) where the patients were asked to relax while sitting in a comfortable upright position to swallow

and relax without separating the lips. The resulted distance of rest vertical dimension was measured using Boley's gauge in mm for which the thickness of splint was made.

Clinical examination using Helkimo Dysfunction Index (HDI):

For all the patients, the index for clinical dysfunction of masticatory system validated by Helkimo (30) was obtained to determine the degree of TMD based on the presence of five symptoms which were:

- impaired range of movement of the mandible,
- impaired function of TMJ,
- pain on movement of the mandible,
- muscle pain and
- pain on palpation of TMJ.

Each of five clinical symptoms were allotted a value if the symptom were present, these values were then totaled and categorized into dysfunction levels (none, slight, moderate and severe).

The Helkimo clinical dysfunction index scores were evaluated prior to fabrication of the splint, two weeks and three months after use of the stabilization splint therapy to assess the degree of TMD.

Results

Table 1: HDI scores of the patients with TMD due to bruxism at baseline, 2 weeks and 3 month after using the SS with its thickness to open the mandible to VDR which determined by Divine proportion method

	HDI		
	Baseline	**After 2 weeks**	**After 3 months**
Divine proportion			
Range	9.0 – 22.0	2.0 – 8.0	0.0 – 2.0
Mean ± SD	16.13 ± 4.02	5.0 ± 1.77	0.50 ± 0.76
Median	16.50	5.0	0.0
p_1		0.012*	0.012*
p_2			0.011*

p_1: p value for Wilcoxon signed ranks test between baseline with each other period
p_2: p value for Wilcoxon Signed ranks test between after 2 weeks and after 2 months

*: Statistically significant at $p \leq 0.05$

Table 1 showed the results of the mean scores of Helkimo dysfunction index of 8 patients with TMD due to bruxism before using the stabilization splint at base line, 2 weeks and 3 months after using the splint with its thickness made to increase vertical dimension up to RVD determined by divine proportion method. The mean scores of HDI were 16.13±4.02, 5.0 ±1.77 and 0.50±0.76 respectively.

On comparing the mean difference of HDI scores of patients with TMD due bruxism before using the stabilization splint, 2 weeks and 3 months after using the splint, the results showed that there was a significant difference of reduction of HDI scores after 2 weeks and 3 months following splint therapy t (p1) 0.012 and t (p2) 0.011 respectively.

When comparing the HDI mean scores 3months after using the splint therapy with HDI mean scores 2 weeks after using the splint therapy, there was a significant reduction in the amount of dysfunction t(p1).012.

Table 2: HDI scores of the patients with TMD due to bruxism at baseine, 2 weeks and 3 month after using the SS with its thickness to open the mandible to VDR which determined by swallowing threshold method.

	HDI		
	Baseline	**After 2 weeks**	**After 3 months**
Conventional method			
Range	7.0 – 25.0	2.0 – 16.0	0.0 – 5.0
Mean ± SD	17.0 ± 5.58	9.38 ± 4.57	2.38 ± 1.77
Median	17.0	9.0	2.50
p_1		0.011*	0.011*
p_2			0.011*

p_1: p value for Wilcoxon signed ranks test between baseline with each other period
p_2: p value for Wilcoxon Signed ranks test between after 2 weeks and after 3 months

*: Statistically significant at $p \leq 0.05$

Table 2 represented the results of HDI mean scores of 8 patients with TMD due to bruxism before using the stabilization splint at base line, 2 weeks and 3 months after using the splint with its thickness made to increase vertical dimension up to RVD

determined by swallowing method (conventional method). The mean scores of HDI were 17.0± 5.58, 9.38± 4.57 and 2.38±1.77 respectively.

The mean difference of HDI scores of all patients was significantly decreased after 2 weeks and 3 months following the splint therapy t (p1) 0.011 and t (p2) 0.011 respectively.

By comparing the HDI mean scores 3 months after using the splint therapy with the mean scores of HDI after 2 weeks of using the splint therapy, there was a significant reduction in the amount of dysfunction t(p1)0.011.

Table 3: Comparison of the HDI scores in patients of the studied groups before and after stabilization splint therapy

	Divine proportion Group I	Conventional method Group II	p
Percentage of change			
Min. – Max.	90.91 – 100.0	76.47 – 100.0	
Mean ± SD	97.46 ± 3.68	87.67 ± 8.74	0.024*
Median	100.0	85.83	

p: p value for Mann Whitney test*: Statistically significant at p ≤0.05.

On comparing the percentage of change of HDI scores in the two studied groups before using the stabilizing splint (base line) and after three month of wearing the splint, the result revealed that the mean difference of HDI scores of the patients in group I was 97.46 ± 3.68 and for the patients in group II was 87.67 ± 8.74 with a significant difference between the two groups (p) 0.024.

Discussion

Several explanations have been offered for the clinical effectiveness of occlusal splints in the reduction of pain and dysfunction associated with the TMJ. Occlusal splints are frequently used in bruxism, to protect teeth from damage resulting from the contraction force of mandibular muscles, or to reduce the orofacial pain by relaxing masticatory

muscles. Moreover, it will compensate for any altering in the vertical dimension of occlusion (9.11,19,31).

Occlusal splints create neuromuscular balance by eliminating occlusal interferences and producing a change in the degree of tactile afferent impulses from the periodontal proprioceptive fibers (1,6,11,19). In addition, occlusal splints reduce bruxing, an important etiologic factor in myospasm that may lead to TMJ syndrome (9,15,32-34).

Occlusal splints are also believed to improve maxillomandibular relationships and thus alter the relationship of the condyle to the fossa (31,35). Furthermore, occlusal splints encourage muscular relaxation, with reduces muscle spasm, as evidenced by a decrease in EMG activity of the mandibular muscles (1,13,15,18,36,37).

The hard type stabilization splint was selected in this study for its superior benefit than the soft appliance referenced by many authors in previous study who concluded that the use of soft stabilization appliances result in occlusal changes(38), increase pain and increase nocturnal electromyographic recordings compared with hard splints.(39)

There is evidence that there is a relationship between muscle hyperactivity and signs and symptoms of mandibular dysfunction. Thus, Vestergaard-Christensen demonstrated that in subjects without signs and symptoms of mandibular dysfunction, muscular pain was reported in the masticatory muscles 30 min after an experimental grinding and clenching exercise (40). Further, Solberg, Clark& Rugh (1975) reported that in subjects with habitual bruxism, the nocturnal cumulative EMG activity in the masseter muscles was significantly reduced when using an occlusal splint (41).

Although, it is accepted that occlusal splints are effective in producing neuromuscular relaxation and reduction of the symptoms of TMD, the amount of occlusal opening required to produce the desired relief of symptoms has not been specifically defined.

In this study, the occlusal splints were constructed in a way the occlusal splint opening increased the VDR position of the mandible which was previously determined by either a conventional method (swallow and relax without lip separation) or a (novel method)

divine proportion method to study the influence of the method of determination of vertical dimension of rest on the clinical symptoms of TMD with bruxism.

Tallgren(42) tested the accuracy of three methods, which are fatiguing the jaw musculature, phonetics, and the "no command" method of physical and mental relaxation in establishing the vertical dimension of rest position cephalometrically on people with normal dentitions. Cephalometric radiographs showed no significant statistical difference when comparing these three methods. Since such methods have been used by many investigators for determination of VDR (29, 43-47), therefore the divine proportion ratio was applied in this study to determine VDR based on facial approximation concept.

All the selected patients underwent clinical investigation according to HDI to assess the degree of TMD before and after the treatment with the stabilization splint. This assumption was based on previous studies that showed HDI was an effective aid in detecting the severity of TMD on clinical bases. (1,30,48)

The results of this study revealed significant reduction in the clinical symptoms of Helkimo dysfunction index scores after 3 month of wearing stabilization splint in the patients of both groups. This result may be attributed to improvement instability of the occlusion by elimination of supra and infra occlusal contacts, so increase of the extent of occlusal contacts. The results suggested that elimination of occlusal interferences by the stabilization splint interrupted the feedback mechanism that supplies the bruxism. This finding also indicates that an increase in vertical dimension to the rest position by the occlusal splint opening must be considered an important factor in effecting a more rapid and more complete remission of TMD symptoms.

Our study is in agreement with some authors who reported that insertion of a plane occlusal splint in patients with signs and symptoms of Craniomandibular disorders with a habit of nocturnal bruxism alters the relationship of the mandible and maxilla causing changes such as redistribution of forces in the masticatory system. They also said that the occlusal splint may have reduced the load on the masticatory muscles in painful regions, with a consequent reduction of inhibitory feed-back to the central nervous system (11,19). Also, Holmgren et al reported that in patients with signs and symptoms of

mandibular dysfunction, the level of EMG activity in all jaw elevator muscles decreased significantly during maximal clenching on the occlusal splint. They related their finding due to fear of pain and fracturing of the teeth may inhibit patients from performing at full capacity (11).

One might expect that an increase in vertical dimension by SS to the rest position of the mandible (VDR) in both groups under study would produce an increase in TMD dysfunction. On the contrary, both groups obtained a significant reduction in the symptoms of TMD dysfunction after SS wearing for three month. This improvement may be due to slight downward condylar displacement as a result of the increase in vertical dimension which lessen the pressure in the capsule and the disc.

This finding agrees with that of Weinberg (49) who concluded that there was a reduction in intra-capsular pressure with an increase in vertical dimension because more joint space is created and lessens the effects of the increased synovial fluid that accompanies joint injury. Pain is therefore reduced because there is less pressure to simulate nerve endings in the capsule and the disk. Ramfjord and Blankenship have also confirmed that an increase in occluding vertical dimension does not have a pathologic effect on the TMJ (50).

Although the mean scores of HDI in both groups under investigation in this study showed significant reduction in the amount of dysfunction after 3 months, also there was a statistical significant difference of the mean score of HDI between both groups after 3 months of using the SS according to percentage of change.

The patients in group 1showed more reduction of TMD symptoms than patients in group 2. This improvement may be due to that the thickness of SS which was fabricated at occlusal opening of rest position of the mandible VDR by Divine proportion method was more effective in reduction of masticatory muscles disorder which is the most commonTMD complaint of the patients seeking treatment.

Our results were supported by some authors who reported that the Divine proportion method relies on mathematical calculations and employs a caliperated guage aligned to static anatomical landmarks as references (22,23,29,47,51).

This caliper depends on the middle part of the face, which is unchangeable and depending on the patient's rest state that has been found on skeletal evidences (52). The current study proved that the use of Divine proportion via golden mean guage is a reproducible, mathematical and objective method which should be used to establish rest vertical dimension to adjust the occlusal thickness of SS rather than depending on swallowing threshold method.

Conclusion

In patients with signs and symptoms of TMD syndrome due to bruxism, a plane occlusal splint (stabilization splint) with occlusal opening up to the VDR could produce relief of symptoms of TMD and interrupt the feed-back mechanism that lead to the bruxism. The temporary use of stabilization splints with occlusal opening not exceeding the rest position of the mandible (VDR) did not encourage muscular hyperactivity and more effective for treatment of signs and symptoms of TMD. The difference between VDR determined by Divine proportion method and conventional swallowing threshold method in dentulous patients with TMD due to bruxism was statistically significant. The divine proportion method gives consistent measurement and should be considered a reliable method for determination of VDR especially in TMD persons.

References

1- Nascimento LL, Amorim CF, Giannasi LC, Oliveira CS, Nacif SR, Silva Ade M, Nascimento DF, Marchini L, de Oliveira LV. Occlusal splint for sleep bruxism: an electromyographic associated to Helkimo Index evaluation. Sleep Breath. **2008** Aug;12(3):275-80.

2- Manfredini D, Lobbezoo F: Relationship between bruxism and temporomandibular disorders:A systemic review of literature from 1998 to 2008.Oral Surg Oral Med Oral Pathol OralRadiol Endod **2010**;109 (6):26-50.

3- Pintado MR., Anderson GC,Delong R, Douglas WH. Variation in tooth wear in young adults over a two-year period. J Prosthet Dent **1997**;77:313-320.

4- Dao TT,. Lund JP,. Lavigne GJ. Comparison of pain and quality of life in bruxers and patients with myofascial pain of masticatory muscles. J Orofac Pain **1994**;8:350-356.

5- Kampe T., Edman G. Bader G, Tagdae T., Karlsson S. Personality traits in a group of subjects with long standing bruxing behaviuor. J of oral rehabil **1997**;24:588-593.

6- Harada, T., Ichiki, R, Tsukiyama Y, Koyano K: The effect of oral splint device on sleep bruxism: a 6-week observation with an ambulatory electromyographic recording device. J of oral rehabil **2006**;33:482-488.

7- Allen J. D., Rivera-Morales W. C., Zwemer J. D. The occurrence of temperomandibular disorder symptoms in healthy young adults with and without evidence of bruxism. J of craniomandibular practice **1990**;8:312.

8- Molina OF, dos Santos J Jr, Nelson SJ, Grossman E. Prevalence of modalities of headaches and bruxism among patients with craniomandibular disorder. Cranio. **1997** Oct;15(4):314-25.

9- Alvarez-Arenal A., Junquera L. M., Pernandez J. P. Effect of occlusal splint and transcutaneous electric nerve stimulation on the signs and symptoms of temperomandibular disorders in patients with bruxism. J of oral rehab **2002**;29:858-863.

10- Yustin D., Neff P., Rieger M.R., Hurst T. Characterization of 86 bruxing patients and long-term study of their management which occlusal devices and another forms of therapy. Journal of Orofacial Pain **1993**;7:54.

11- Holmgren K., Sheikholeslam A., Riise C., Kopp S. The effect of an occlusal splint on the electromyographic activities of the temporal and masseter muscles during maximal clenching in patients with a habit of nocturnal bruxism and signs and symptoms of Craniomandibular disorders. J of Oral Rehab **1990**;17:447-459.

12- Major P.W., Nebbe B. Use and effectiveness of splint appliance therapy:review of literature. Journal of craniomandibular practice **1997**;15:159.

13- Manns A., Miralles R., Santander H., Valdivia J. Influence of the vertical dimension in the treatment of myofascial pain-dysfunction syndrome. J Prosthet Dent **1983**;50:700-709.

14- pettengill, C A., Growney, M R. Schoff R, Kenworthy C R. A pilot study comparing the efficacy of hard and soft stabilizing appliances in treating patients with temperomandibular disorders. J Prosthet Dent **1998**;79:165-80.

15- Roark A. L., Glaros A. G., O'Mahony A. M. Effects of Interocclusal appliances on EMG activity during parafunctional tooth contact. J Oral Rehabil **2003**;30:573-577.

16- Jokstad A., Mo A., Krogstad B.S. Clinical comparison between two different splint designs for temperomandibular disorder therapy. Acta Odontologica Scandinavica **2005**;63:218-226.

17- Humsi A. N. K., Naeiji M., Hippe J. A., Hansson T. L. The immediate effects of a stabilization splint on the muscular symmetry in the masseter and anterior temporal muscles of patients with a Craniomandibular disorder. J Prosthet Dent **1989**;62:339-343.

18- Niemelä K, Korpela M, Raustia A, Ylöstalo P, Sipilä K. Efficacy of stabilisation splint treatment on temporomandibular disorders. J Oral Rehabil. 2012 Nov;39(11):799-804. doi: 10.1111/j.1365-2842.2012.02335.x. Epub **2012** Jul 19.

19- Sheikholeslam A., Holmgren K., Riise C. A clinical and electromyographic study of the long-term effects of an occlusal splint on the temporal and masseter muscles in patients with functional disorders and nocturnal bruxism. J Oral Rehabil **1986**;13:137-145.

20- Kawazoe Y., Kotani H., Hamada T., Yamada S. Effect of occlusal splints on the electromyographic activities of master muscles during maximum clenching in patients with myofascial pain-dysfunction syndrome. J Prosthet Dent **1980**;43:578-580.

21- Roura N., Clayton J.A. Pantographic records on TMJ dysfunction subjects treated with occlusal splints: A progress report. J Prosthet Dent **1975**;33:442.

22- Lindblom, Mike. "High-Wire Act". The Seattle Times. September 11, 2005. Retrieved 2008-05-27.

23- E L EL Gottlieb. Is there a golden ratio? J Clin Orthod 35(12):721-**2001**, PMID 11822293.

24- Huntley, H. E.. The Divine Proportion: A Study in Mathematical Beauty. New York: Dover Publications. **1970**. ISBN 0-486-22254-3.

25- Preston JD. The Golden Proportion revisited. *J Esthet Dent*. **1993**;5:247-251.

26- Mohammed Aleem Abdullah, Inner canthal distance and geometric progression as a predictor of maxillary central incisor width The Journal of Prosthetic Dentistry**.** Volume 88, Issue 1, July 2002, Pages 16–20.

27- Maloney WJ, Fried J . Vitruvian Man - Leonardo da Vinci's Interpretation of the Golden Proportion and its Application in Modern Dentistry. WebmedCentral DENTISTRY 2011;2(4):WMC001879.

28- Shoemaker WA. How to take the guesswork out of dental esthetics and function. Part II. Fla Dent J. **1987** Winter;58(4):25-6, 28-9.

29- Soliman IS. Verification of the methods for registering vertical dimension in relation to the divine proportion for edentulous cases. Master Thesis, Faculty of Dentistry, Alexandria University, **2011**.

30- Helkimo M. Studies on function and dysfunction of masticatory system. Part **II**. Index for anamnestic and clinical dysfunction and occlusal state. Swed Dent J **1974**;67:101-121.

31- Machado NA, Fonseca RB, Branco CA, Barbosa GA, Fernandes Neto AJ, Soares CJ.Dental wear caused by association between bruxism and gastroesophageal reflux disease: a rehabilitation report. J Appl Oral Sci. **2007** Aug;15(4):327-33.

32- Clark GT, Beemsterboer PL, Rugh JD.Nocturnal masseter muscle activity and the symptoms of masticatory dysfunctionJournal of Oral Rehabilitation. Volume 8, Issue 3, pages 279–286, May **1981**.

33- Solberg WK, Clark GT, Rugh JD. Nocturnal electromyographic evaluation of bruxism patients undergoing short term splint therapy. J Oral Rehabil. **1975** Jul;2(3):215-23.

34- Manns, A. Miralles, R and Adrian H. The application of audiostimulation and EMG biofeedback to bruxiam and myofascial pain dysfunction syndrome. Oral Surg 52:247-, **1981**.

35- Weinberg, L The etiology, diagnosis and treatment of TMJ dysfunction pain syndrome. Part3: treatment. J prosthet Dent 43:186, **1980**.

36- The changes in electrical activity of the postural muscles of the mandible upon varying the vertical dimension Manns A, Miralles R, Guerrero F. The Journal of Prosthetic Dentistry. Volume 45, Issue 4, April **1981**, Pages 438–445.

37- Christensen, LV: Effects of an occlusal splint on integrated electromyography of masseter muscle in experimental tooth clenching in man. J oral Rehabil 7:281, **1980**.

38- Nevarro, E Barghi N, Rey R. Clinical evaluation of maxillary hard resilent occlusal splints. (abstract 1246). J Dent Res **1985**; 64 (special issue): 318.

39- Okeson. JP. The effects of hard and soft occlusal splints on nocturnal bruxism.JADA **1987**;54, 711-715.

40- L.Vestergaard Christensen. Facial pain and internal pressure of masseter muscle in experimental bruxism in man. Archives of Oral Biology. Volume 16, Issue 9, September **1971**, Pages 1021–1031.

41- Solberg W., Clark G., Rugh J. Nocturnal electromyographic evaluation of bruxism patients undergoing short-term splint therapy. J Oral Rehab **1975**;2 (3):215-223.

42- Tallgren A. Changes in adult face height due to ageing, wear and loss of teeth and prosthetic treatment. Acta Odontol Scand. **1957**; 15; 100-112.

43- Heath MR. The contact-relax method . To establish "the rest position" and assess the inter-occlusal distance. Br Dent J; **1980**; 149; 181-182.

44- Jacop RF. The traditional therapeutic paradigm. Complete denture therapy. Journal of Prost Dent: **1998**; 79: 6-13.

45- Toolson LB, Smith DE. Clinical measurement and evaluation of vertical dimension. J Prosthet Dent;**1982**; 47:235-241.

46- Silverman MM. The speaking method in measuring vertical dimension. 1952. J Prosthet Dent. **2001**; 85: 427-431.

47- Banasr F, Al-Rafah EM; Evaluation of divine proportion ratio as a method for registration of rest vertical dimension using statistical analysis in completely edentuolous patients. Smile Dental J **2012**; 7(1): 44-49.

48- El-Rafah EM, Warda MH, Fata MM. Clinical, pantographic and magnetic resonance imaging evaluation of patients with temoromandibular joint dysfunction before and after orthognathic surgery. Egyptian Dental J **2002**; 48(4); 1833;1842.

49- Weinberg,L: Vertical dimension:A research and clinical analysis. J Prosthet Dent.47:290,**1982**.

50- Ramfjord S and Blankenship, J. Increased occlusal vertical dimension in adult monkeys. J Prosthet Dent **1982**; 45: 74.

51- Ferring V, Pancherz H: Divine proportion in the growing face. Am J orthod Dentofacial Orthop. **2008**; 134(4): 472-479.

52- Wahl N. Orthodontics in 3 millennia. Chapter 7: facial analysis before the advent of cephalometer. Am J Orthod Dentofacial Orthop **2006**;129:293-298.