2008년 8월
석사학위 논문

Evaluation of TMJ sound on the subject with TMJ disorder by JVA

조선대학교 대학원

치 의 학 과

황 인 택

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JVA를 이용한 악관절 장애환자의 관절잡음 음파 분석

2008년 8월 25일

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이 논문을 치의학 석사학위신청 논문으로 제출함

2008년 4월

조선대학교 대학원

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측두하악 관절잡음의 진동 분석

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측두하악악관절장애의 주증상과 기능장애는 변화된 과두-원판 기능과 관련된 것이다. 기능장애의 증상은 과두운동과 관계가 있으며, 일반적으로 관절의 걸림과 관절잡음으로 표현된다. 관절잡음의 발생은 관절내장증과 관절내 부하의 변화에 대한 일시적 현상으로 관절내장증으로 인한 관절 잡음의 경우 관절원판 인대가 늘어나면서 전내방으로 변위된 관절원판 위로 하악 과두가 관절원판 후방부를 뛰어넘어 중간부로 이동함으로써 발생하기 시작하며 개폐구위에서 발생하는 관절음의 위치와 크기에 따라 관절원판의 형태변화 및 변위정도를 예측하게 된다. 이러한 관절잡음을 평가하는데 electrovibratography가 비침습적이고 신뢰할만한 방법으로 제시되어 왔으며 이를 통해 관절잡음의 진동수와 진폭 및 전체 에너지 양상을 숫자화하고 도식화하는 것이 가능하게 되었다.

본 연구의 목적은 electrovibratography를 이용한 관절 잡음의 분석법으로 integral>300/<300 Ratio와 frequency spectrum을 활용하여 관절잡음의 특성을 장기적으로 분석하는데 있다.

본 실험에서는 Joint Vibration Analysis^{TM}를 사용하여 측두하악관절 장애의 증상이 없는 10명의 group Ⅰ과 관절잡음과 동통이 있으나 개구제한을 보이지 않는 정복성 관절원판 변위의 범주에 있는 10명의 group Ⅱ에서 6개월 전을 대조군으로, 6개월 후를 실험군으로 하여 관절잡음을 기록하였으며 관절잡음 기록 시에 Jaw tracker를 함께 사용하여 개폐구시 관절잡음 발생의 위치를 감별하고 치아접촉음을 배제하여 관절잡음을 분석하였다.

No. 1-10은 group Ⅰ, 11-20은 group Ⅱ이며, 각각 6개월 전과 6개월 후의

integral>300/<300 Ratio를 나타내고 있다. 본 연구에서는 모든 개체에서 ratio값이 변화함을 관찰하였으며 frequency spectrum과의 비교에서 다음과 같은 결과를 얻었다. 1.개폐구 주기에서 악관절 잡음의 소리가 발생하는 위치가 비슷한 경우 integral>300/<300 Ratio가 다르더라도 frequency spectrum은 비슷한 양상을 보였다. 2.개폐구 주기에서 악관절 잡음의 소리가 발생하는 위치가 다른 경우 integral>300/<300 Ratio뿐만 아니라 frequency spectrum도 다른 양상을 보이며 이는 악관절 잡음의 기계적 특성이 시간에 따라 변화할 수 있다는 것을 보여주는 것으로 사료된다.

악관절 잡음 치료의 시점을 결정하는데 integral>300/<300 Ratio만으로 기준을 설정하는 것은 충분치 않으며 악관절 잡음을 분석함에 있어 integral>300/<300ratio뿐만 아니라 frequency spectrum, 임상 증상 등을 종합적으로 고려해야 함을 알 수 있었다.

Ⅰ. *INTRODUCTION*

Derangements of the condyle-disc complex arise from a breakdown of the normal rotational movement of the disc on the condyle. The thinning of the posterior border of the disc can cause the disc to be displaced in a more posterior position. With the condyle resting on a more posterior portion of the disc or retrodiscal tissues, an abnormal translatory shift of the condyle over the posterior border of the disc can occur during the opening. A click is associated with the abnormal condyle-disc movement and may be initially felt just during opening (single click) but later may be felt during opening and closing of the mouth (reciprocal clicking).[1)]

Molinari et al.[2)] reported that occasionally a second clicking sound is heard during mouth closure (reciprocal click), because the posterior band of the disc slips forward off the condyle. Other clicking sounds can also be produced by irregularities or defects in the surface of the disc or by changes in the convexity of the condylar and/or articular eminence. These sounds are usually less obvious than those caused by anterior disc displacement. They are also found at the same point of the temporomandubular joint(TMJ) traslator movement rather than at different points, as occurs with reciprocal clicking.

Clicking and crepitation should be considered signs of morphological alterations, being indicative of anterior disk displacement with reduction[3)] and arthrosis, respectively. Electrovibratographic records and macroscopic examinations of articulations of corpses showed that 20% of the TMJs with clicking had the disk displaced anteriorly and 22% of the TMJs with crepitation had arthrosis or disk perforation.[4)] Later recapture of the disk causes clicking at the end of mouth opening and indicates that the bilaminar zone is more affected.[5)] The microscopic aspects of the disk surface can also be altered.[6)]

Qualitative and semi-quantitative methods have been developed for TMJ

sound classification, but the criteria presented are completely inhomogeneous.[7-12] Thus, to develop more objective criteria for defining TMJ sounds, electroacoustical systems have been developed.[7-9, 11-15]

We used Joint vibration analysis(JVA) in the BioPAK system (Bioresearch, Inc, Milwaukee, USA) as the electrovibratography, and Jaw tracker(JT)-3 device in the BioPAK system (Bioresearch, Inc, Milwaukee, USA). Using JT-3 deivce allowed the computer to estimate where a joint vibration occurs in the open/close cycle and let us distinguish tooth contact from joint sound precisely.

Ishigaki et al.[17] reported a disc displacement with reduction generates a "click" in the lower frequencies (under 300Hz) and a degenerative condition generates "crepitus" in the higher frequencies (over 300Hz). In the previous study, we found that in an integral >300Hz/<300Hz ratio it is conceivable that the higher the integral >300Hz/<300Hz ratio number, a more advanced degenerative condition exists. Gallo et al[16] reported that TMJ clicking was subjectively and objectively stable over a period or 10 days. We found few studies about long term follow-up based on the frequency spectrum patterns associated with the integral >300Hz/<300Hz ratio. The aim of this study was to examime the TMJ sounds with repect to frequency spectra patterns and the integral >300 Hz/<300Hz ratio with a 6 month follow-up.

Ⅱ. *MATERIALS AND METHODS*

Twenty dental school students (18 males and 2 females: age range 25-34 years old; mean age=22.4 years old) participated in the before (control group) and after (experimental group) six-month joint sound recordings. Group Ⅰ(8 males and 2 females) was composed of the subjects that showed anterior disk displacement with reduction. They were selected by means of clinical examinations. As inclusion criteria, all subjects had clicking in both TMJs upon mouth opening and/or closing and a normal range of jaw movement during opening and/or pain at palpation (any of the masseter, temporalis, pterygoid, digastric muscles) and jaw movement during chewing. Group Ⅱ (10 males) was composed of subjects that showed a normal state of TMJ. They showed absence of TMJ noises, pain at palpation (any of the masseter, temporalis, pterygoid, digastric muscles) and jaw movement or chewing.

In each subject, EVG analysis was performed three times. A magnet was attached to the labial surface of mandibular incisors of the subjects in order to bring the midline of the magnet to the labial frenum and to locate the groove of the magnet to the left side of the subjects. If the subject tended to have a deep bite so that it is impossible to attach the magnet, it was attached to the labial gingival surface or lingual tooth surface. One transducer was placed on the skin over the right TMJ, and the other over the left TMJ. Then the JT-3 device was set on the subjects. Once the horizontal and vertical standard points were set, we controlled them to fit with the subjects' heads. The bar of the front side was kept parallel to the interauditory axis and the lateral side to the Frankfort Horizontal plane. The accessory bar for approaching the magnet was fixed temporally and operated in order to set the exact midline.

As the subject performed metronome-guided maximun active

opening/closing with the JVA, the condyles rubbed against the various surfaces in the joint, creating characteristic vibrations which are then, in turn, detected by the accelerometers, which convert those specific vibrations into an electronic signal. The signal from the accelerometers is amplified by a small, light-weight amplifier which is placed around the patient's neck. The amplified signals are then transmitted to a PC computer where they are recorded and analyzed with a software program, then displayed on a CRT. After the best recording was selected from three, vibrations showing the highest amplitude were screened priorly. When we excluded tooth contact precisely, reproducible joint sound was analyzed for each opening & closing cycle. Finally, an averaged episode was detected in each subject.

After subject selection, the largest vibration amplitude consistently occurring in each joint recording was used to calculated frequency spectrum computed by the Fast Fourier Transform (FFT) algorithm. The numeric values that are calculated and displayed in the JVA summary view are based on the absolute frequency spectra. The frequency spectra view plots amplitude (vertical axis) versus frequency (horizontal axis). The height of the curve is directly proportional to the energy of the spectrum at each frequency. The thick line represents the average spectrum of all the marked vibration spectra. Two spectra are plotted for each side: the smaller of the two represents the absolute magnitude of the vibrations' spectra as recorded (N/m^2), the larger one has been scaled to the maximum range (at the recorded amplification) and is known as the relative plot. The relative plot accentuates features that may not be visible in the absolute plot.(Fig.1.)

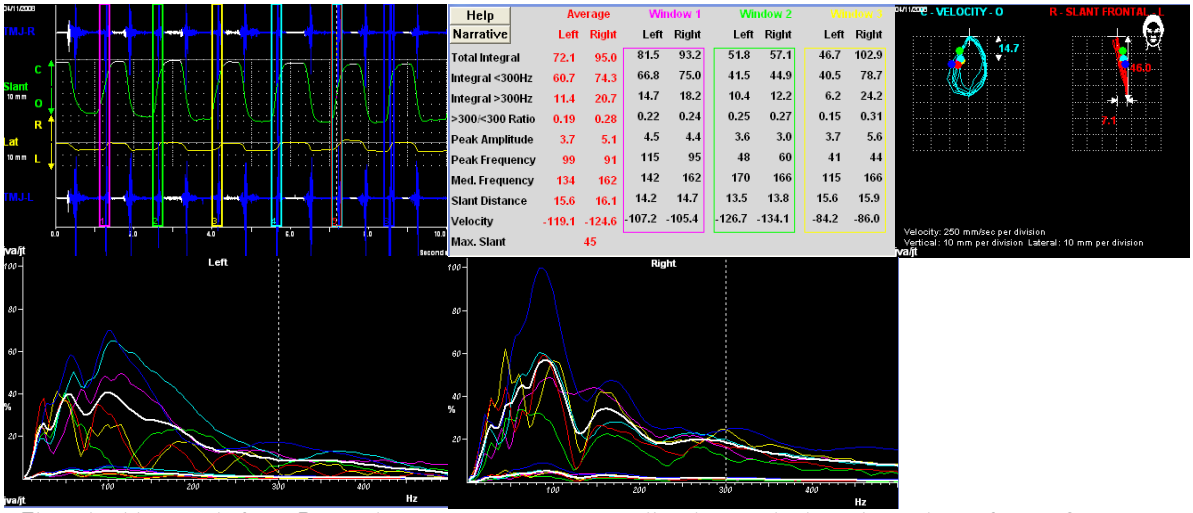


Fig. 1. Upper left : Raw data represents amplitude and duration data from 6 open/close cycles., Upper middle : the JVA summary represents numerics which are based upon absolute frequency spectra. Upper right : superimposed opening and closing cycles representing location of the joint sounds. Lower : the Frequency spectrum computed from the Fast Fourier Transform Algorithm.

Ⅲ. *RESULT*

The integral >300/<300 ratios in Group Ⅰ and Group Ⅱ listed in Table 1. and Table 2. show variations before and after six-month recordings respectively. In Group Ⅱ, joint sound was not found on clinical examinations but detected by JVA recordings. Also, No. 17-20 showed Integral >300/<300 Ratios disappeared six-month later.

No.		Before 6 month	After 6 month
1	Lt. Ratio	0.33	0.19
	Rt. Ratio	0.13	0.28
2	Lt. Ratio	0.09	0.13
	Rt. Ratio	0.07	0.19
3	Lt. Ratio	0.3	0.13
	Rt. Ratio	0.17	0.2
4	Lt. Ratio	0.25	0.06
	Rt. Ratio	0.07	0.05
5	Lt. Ratio	0.09	0.17
	Rt. Ratio	0.05	0.15
6	Lt. Ratio	0.07	0.37
	Rt. Ratio	0.12	0.12
7	Lt. Ratio	0.38	0.14
	Rt. Ratio	0.26	0.17
8	Lt. Ratio	0.08	0.05
	Rt. Ratio	0.09	0.14
9	Lt. Ratio	0.25	0.25
	Rt. Ratio	0.44	0.18
10	Lt. Ratio	0.15	0.11
	Rt. Ratio	0.19	0.29

Table 1. Integral >300/<300 Ratios in Group Ⅰ recorded before and after six-month, respectively (subjects No.1-10). In all subjects the Integral >300/<300 ratios were varied from six-month early recordings.

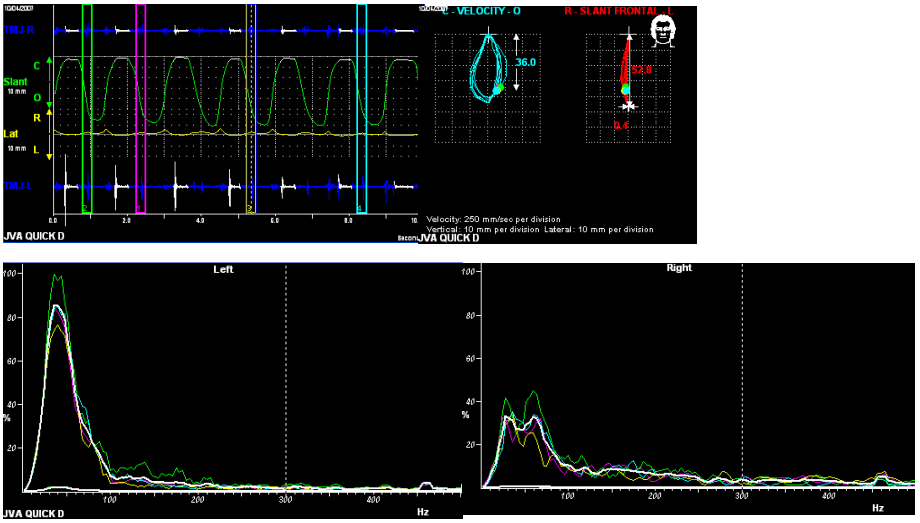
No.		Before 6 month	After 6 month
11	Lt. Ratio	0.04	0.08
	Rt. Ratio	0.02	0.06
12	Lt. Ratio	0.13	0.06
	Rt. Ratio	0.13	0.05
13	Lt. Ratio	0.07	0.08
	Rt. Ratio	0.19	0.16
14	Lt. Ratio	0.14	0.06
	Rt. Ratio	0.09	0.06
15	Lt. Ratio	0.2	0.09
	Rt. Ratio	0.3	0.15
16	Lt. Ratio	0.18	0.08
	Rt. Ratio	0.14	0.11
17	Lt. Ratio	0.18	—
	Rt. Ratio	0.1	—
18	Lt. Ratio	0.05	—
	Rt. Ratio	0.09	—
19	Lt. Ratio	0.13	—
	Rt. Ratio	0.08	—
20	Lt. Ratio	0.1	—
	Rt. Ratio	0.15	—

Table 2. Integral >300/<300 ratios in Group II were recorded before and after six-month, respectively (subjects No.11-20). While No.17-20 showed Integral >300/<300 ratios disappeared in six months, in all subjects the Integral >300/<300 ratios were varied from the ones recorded six months earlier.

The integral >300/<300 ratios and the frequency spectra were analyzed in all subjects. The frequency spectra in some subjects showed similar patterns while the others showed varied patterns.

By the comparative study between the integral >300/<300 ratios and the frequency spectrums, it was conceivable that the frequency spectrums showed similar patterns at the same location that the joint sound occurred between before and after six-months recordings. While the frequency spectra showed varied patterns at the different location that the joint sound occurred in before and after six-month recordings. (Fig.2,3)

(A)



(B)

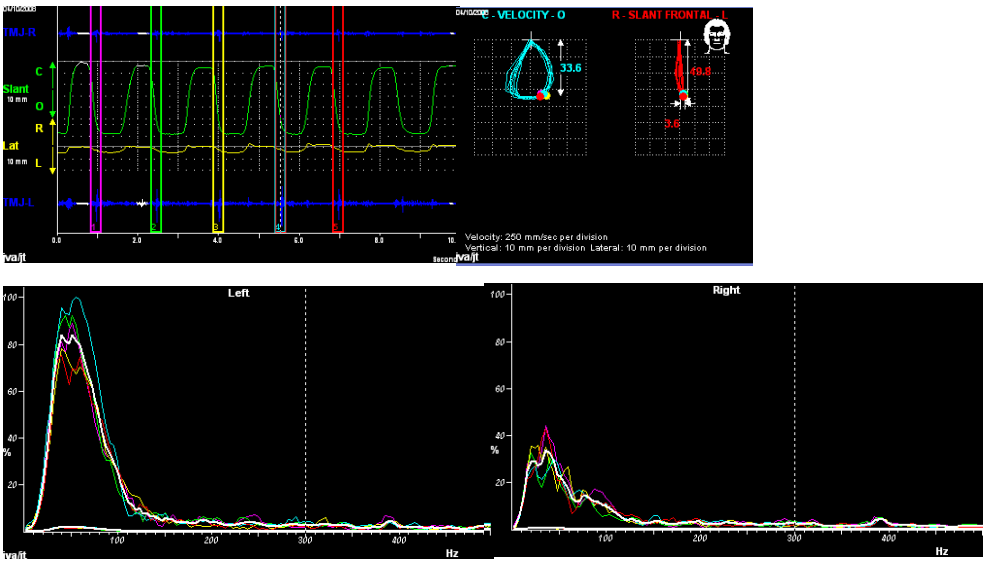
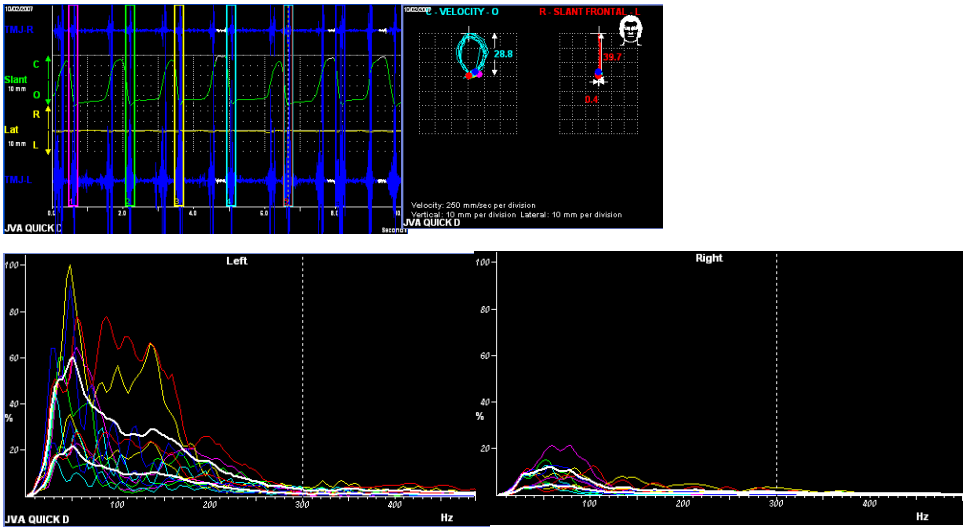


Fig.2. Subject No.13 in Group II showed joint sounds on the late opening cycles. Upper; before six-month recordings showed 0.07 and 0.09 integral >300/<300 ratios, repectively. Lower; after six-month recordings showed 0.08 and 0.16 integral >300/<300 ratios, repectively. Although the integral >300/<300 ratios were different, the frequency spectra showed similar patterns.

(A)



(B)

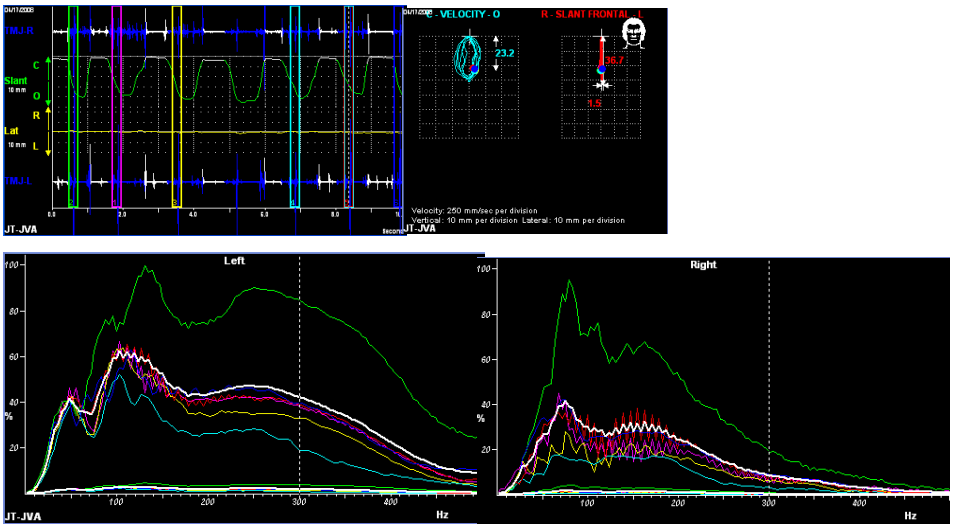


Fig.3. Subject No. 6 in Group I showed joint sounds on the late opening cycles (before six-month) and the middle opening cycles (after six-month). Upper; before six-month recordings showed 0.07 and 0.12 integral >300/<300 ratios, repectively. Lower; after six-month recordings showed 0.37 and 0.12 integral >300/<300 ratios, repectively. As the integral >300/<300 ratios were different, the frequency spectra showed various patterns.

Ⅳ. *DISCUSSION*

Disc displacement is characterized by a normal range of jaw movement during opening and eccentric movements. When reciprocal clicking is present, the two clicks normally occur at different degrees of mouth opening, with the closing click usually occuring near the intercuspal position.[1)]

Although physiological changes occur in the disc, its ability to remodel is lower than that of other tissues of the TMJ, such as the capsule, capsular ligaments, and retrodiscal tissues. Decreased vascularity and extensive fibrous transformation have been reported in the retrodiscal tissue for continuous compression and shear. These adaptative changes can also have mechanical implications on the behavior of the articular disc. However, as long as the system preserves the ability to adapt to the new functional status, the altered mechanical loading is compensated for by the structural modeling of the TMJ. Although the coordination of the disc-condyle complex may be lost in this stage, the patient is usually asymptomatic.[2)]

Garcia et al.[19)] reported that some patients present alterations in the structure of the arcitular disk located in several areas. Small vibrations in the position of the condyle may induce unstable areas with production of articular vibrations.

Using electrovibratography, it is possible to identify and show: 1. The frequencies (in Hertz), as well as the amplitude of the vibration can be expressed mathematically. i.e., Numeric analysis; 2. The visualization of the types of waves created by the sound. i.e., Graphic analysis; 3. The precise moment of the sound generated in the opening and closing cycles.

In this study Group I and Group II showed varied integral >300/<300 ratios before and after six-month recordings. Also, by the comparative study between the integral >300/<300 ratios and the frequency spectrums, it was conceivable that the frequency spectrums showed similar patterns at the same location that the joint sound occurred before and after six-month

recordings. while the frequency spectrums showed varied patterns at the different locations that the joint sound occurred before and after six-month recordings. It would possibly be because of the differences in the degree of internal derangement and/or in the shape of the disc.

SUMMARY

We used Joint vibration analysis (JVA) in the BioPAK system (Bioresearch, Inc, Milwaukee, USA) as the electrovibratography, and Jaw tracker (JT)-3 device in the BioPAK system (Bioresearch, Inc, Milwaukee,USA) to distinguish tooth contact from joint sound precisely. The aim of this study was to examime the TMJ sounds with repect to frequency spectra patterns and the integral >300 Hz/<300Hz ratios via six-month follow-up.

This study was done before (control group) and after (experimental group) six-month recordings with 20 dental school students whose ages ranged from 25 to 34 years with a mean average of 22.4 years. Group I (8 males and 2 females) was composed of the subjects that showed anterior disk displacement with reduction, and were selected by means of clinical examinations. As inclusion criteria, all subjects had clicking in both TMJs upon mouth opening and/or closing and a normal range of jaw movement during opening and/or pain at palpation and chewing movement. Group II (10 males) was composed of the subjects showing a normal state of TMJ. They showed absence of TMJ noises, pain at palpation and chewing movement. In each subject EVG analyses were performed three times and the best recording was selected from the three recordings. Vibrations showing the highest amplitude of priorly tooth contact were exculded and reproducible joint sound was analyzed for each opening & closing cycle. Finally, an averaged episode was detected in each subjet.

Joint vibrations were analyzed using a mathematical technique known as the Fast Fourier Transform (FFT). The frequency spectra view plots amplitude (vertical axis) versus frequency (horizontal axis).

In this study Group I and Group II showed varied integral >300/<300 ratios before and after six-month recordings. Also, by the comparative study between the integral >300/<300 ratios and the frequency spectrums, it was conceivable that the frequency spectrums showed similar patterns at the

same location that the joint sound occurred before and after six-month recordings. while the frequency spectrums showed varied patterns at the different locations that the joint sound occurred before and after six-month recordings. It would possibly be due to the differences in the degree of internal derangement and/or in the shape of the disc.

It is suggested that clinicians consider the integral >300/<300 ratios as well as the frequency spectrums to decide the starting-point of the treatment for TMJ sounds. Therefore JVA will provide the clinician with the visible patterns of TMJ sounds for patient management.

References

1. Okesson JP. Joint Intracapsular Disorders:Diagnosis and Nonsurgical management considerations. Den clin N Am.51(2007)85-103.

2. Molinari F., Manicone P.F., Raffaelli L. et al., Temporomandibular joint Soft-Tissue Pathology, 1 : Disc Abnormalities. Semin Ultrasound CT MRI (2007)28:192-204.

3. Muhul ZF, Sadowsky C, Sakols EI. Timing of temporomandibular joint sounds in orthodontic patients. J Dent Res 1987;66:1389-1392.

4. Rohlin M, Westesson PL, Eriksson L. The correlation of temporomandibular joint sounds with joint morphology in fifty-five autopsy specimens. J Oral Maxillofac Surg 1985;43:194-200.

5.Taskay-Yilmaz N, Ogutcen-Toller M. Magnetic resonance imaging evaluation of temporomandibular joint disc deformities in relation to type of disk displacement. J Oral Maxillofac Surg 2001;59:860-865.

6. McNeill CH. Science and practice of occlusion. Chicago:Quintessence; 2000.

7. Eriksson L, Westesson PL, Rohlin M. Temporomandibular joint sounds in patients with disc displacement. Int J Oral Surg 1985;14:428-436.

8. Watt DM, McPhee PM. An analysis of temporomandibular joint sounds. J Dent 1983;11:346-355.

9. Oster C, Katzberg RW, Tallents RH, et al., Characterization of temporomandibular joint sounds. A preliminary investigation with arthrographic correlation. Oral Surg Oral Med Oral Pathol 1984;58:10-16.

10. Gale EN, Gross A. An evaluation of temporomandibular joint sounds. J Am Dent Assoc 1985;111:62-63.

11. Watt DM. Temporomandibular joint sounds. J Dent 1980;8:119-127.

12. Gay T, Bertolani CN. The spectral properties of temporomandibular joint sounds. J Dent Res 1987;66:1189-1194.

13. Findlay IA, Kilpatrick SJ. An analysis of the sounds produced by the

mandibular joint. J Dent Res 1960;30:1163-1171.
14. Messenger KL, Barghi N. The effect of function and rest on the amplitude of the TMJ click. J Oral Rehabil 1987;14:261-266.
15. Mohl ND, Lund JP, Widmer CG, et al., Devices for the diagnosis and treatment of temporomandibular disorders. Part II :Electronyography and sonography. J Prosthet Dent. 1990;63:332-336.
16. Gallo LM, Svoboda A, Palla S. Reproducibility of temporomandibular joint clicking. J Orofac Pain 2000;14:293-302.
17. Ishigaki S, Bessette RW, Maruyama T. Vibration Analysis of the Temporomandibular Joints with Meniscal Displacement With and Without Reduction. J Craniomandib. Prac. 1993;11:192-201.
18. Ishigaki S, Bessette RW, Maruyama T. Vibration Analysis of the Temporomandibular Joints with Meniscal Displacement With Degenerative Joint Disease. J Craniomandib. Prac. 1993;(11):276-283.
19. Garcia A.R., Folli S., Zuim P.R.J et al., Mandibule protrusion and decrease of TMJ sounds:An Electrobitratographic examination. Braz Dent J (2008) 19(1):77-82.

저작물 이용 허락서

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	영문 : Vibration Analysis of the Temporomandibular Joint Sounds				

본인이 저작한 위의 저작물에 대하여 다음과 같은 조건아래 조선대학교가 저작물을 이용할 수 있도록 허락하고 동의합니다.

- 다 음 -

1. 저작물의 DB구축 및 인터넷을 포함한 정보통신망에의 공개를 위한 저작물의 복제, 기억장치에의 저장, 전송 등을 허락함
2. 위의 목적을 위하여 필요한 범위 내에서의 편집·형식상의 변경을 허락함. 다만, 저작물의 내용변경은 금지함.
3. 배포·전송된 저작물의 영리적 목적을 위한 복제, 저장, 전송 등은 금지함.
4. 저작물에 대한 이용기간은 5년으로 하고, 기간종료 3개월 이내에 별도의 의사표시가 없을 경우에는 저작물의 이용기간을 계속 연장함.
5. 해당 저작물의 저작권을 타인에게 양도하거나 또는 출판을 허락을 하였을 경우에는 1개월 이내에 대학에 이를 통보함.
6. 조선대학교는 저작물의 이용허락 이후 해당 저작물로 인하여 발생하는 타인에 의한 권리 침해에 대하여 일체의 법적 책임을 지지 않음
7. 소속대학의 협정기관에 저작물의 제공 및 인터넷 등 정보통신망을 이용한 저작물의 전송·출력을 허락함.

동의여부 : 동의(O) 반대( )

2008년 2월 25 일

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