Evaluation of TMJ sound on the subject with TMJ disorder by Joint Vibration Analysis

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STATEMENT OF PROBLEM. Qualitative and semi-quantitative methods have been developed for TMJ sound classification, but the criteria presented are completely inhomogeneous. Thus, to develop more objective criteria for defining TMJ sounds, electroacoustical systems have been developed. We used Joint vibration analysis in the BioPAK system (Bioresearch Inc., Milwaukee, USA) as the electrovibratography. **PURPOSE.** The aim of this study was to examine the TMJ sounds with repect to frequency spectra patterns and the integral > 300 Hz /< 300 Hz ratios via six-months follow-up. **MATERIAL AND METHODS.** This study was done before and after the six-months recordings with 20 dental school students showed anterior disk displacement with reduction. Joint vibrations were analyzed using a mathematical technique known as the Fast Fourier Transform. **RESULTS.** In this study Group Ⅰ and Group Ⅱ showed varied integral > 300 /< 300 ratios before and after the six-months 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 the six-months 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. **CONCLUSIONS.** 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.
KEY WORDS. Joint Vibration analysis, Temporaromandibular joint, Joint sound, Electrovibratography **[J Adv Prosthodont 2009;1:26-30]**

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 300 Hz) and a degenerative condition generates "crepitus" in the

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higher frequencies (over 300 Hz). In the previous study, we found that in an integral > 300 Hz /< 300 Hz ratio it is conceivable that the higher the integral > 300 Hz /< 300 Hz 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 > 300 Hz /< 300 Hz ratio. The aim of this study was to examine the TMJ sounds with repect to frequency spectra patterns and the integral > 300 Hz /< 300 Hz ratios via six-months follow-up.

MATERIAL 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) the six-months 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 calculate 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

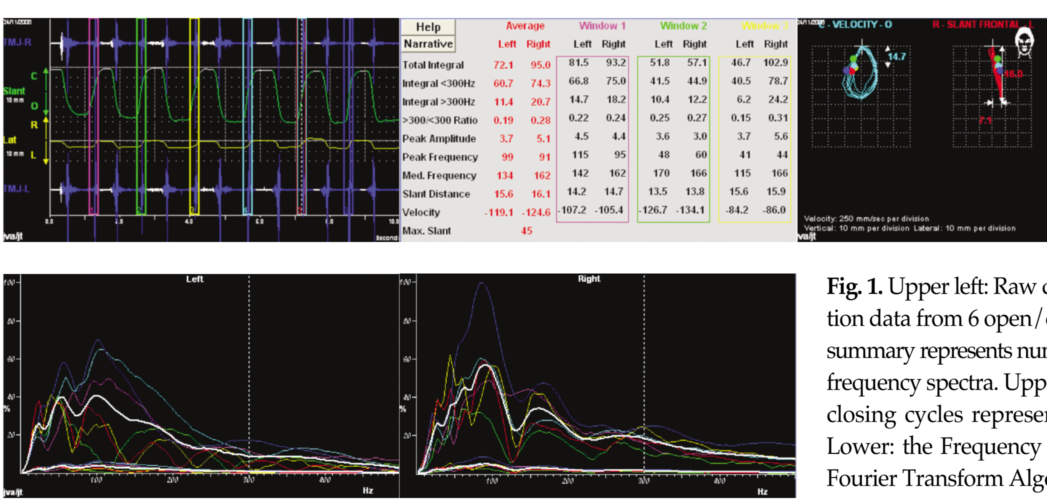

Fig. 1. Upper left: Raw data represents amplitude and duration data from 6 open/close cycles. Upper middle: the JVA summary represents numerics which are based upon absolute frequency spectra. Upper right: superimposed opening and closing cycles representing location of the joint sounds. Lower: the Frequency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

in the absolute plot (Fig. 1).

RESULTS

The integral > 300 /< 300 ratios in Group I and Group II listed in Table I and II show variations before and after the six-months 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-months later.

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 the six-months recordings. While the frequency spectra showed varied patterns at the different location that the joint sound occurred in before and after the six-months recordings (Fig. 2, 3).

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 the after six-months

Table I. Integral > 300 /< 300 Ratios in Group I recorded data, and again after six-months (subjects No.1 - 10). In all subjects the Integral > 300 /< 300 ratios were variable from six-months early recordings

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	0.30	0.13
	Rt. Ratio	0.17	0.20
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 II. Integral > 300 /< 300 ratios in Group II were recorded once and again after six-months (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 variable from the ones recorded six months earlier

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	0.20	0.09
	Rt. Ratio	0.30	0.15
16	Lt. Ratio	0.18	0.08
	Rt. Ratio	0.14	0.11
17	Lt. Ratio	0.18	–
	Rt. Ratio	0.10	–
18	Lt. Ratio	0.05	–
	Rt. Ratio	0.09	–
19	Lt. Ratio	0.13	–
	Rt. Ratio	0.08	–
20	Lt. Ratio	0.10	–
	Rt. Ratio	0.15	–

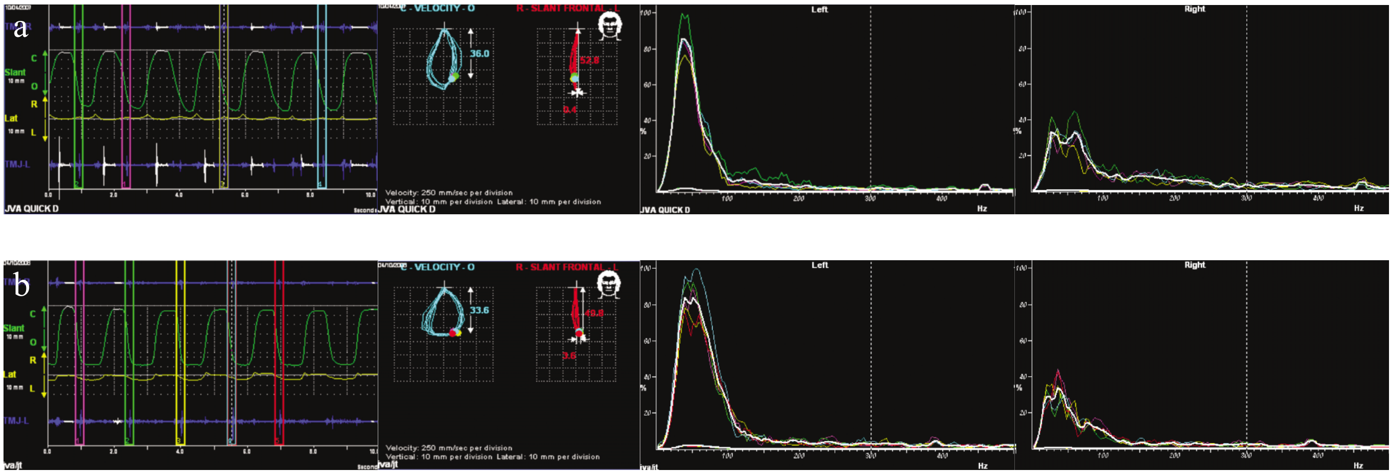

Fig. 2. Subject No.13 in Group II showed joint sounds on the late opening cycles.
(a); before six-months recordings showed 0.07 and 0.09 integral > 300 /< 300 ratios, repectively. (b); after the six-months recordings showed 0.08 and 0.16 integral > 300 /< 300 ratios, repectively. Although the integral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

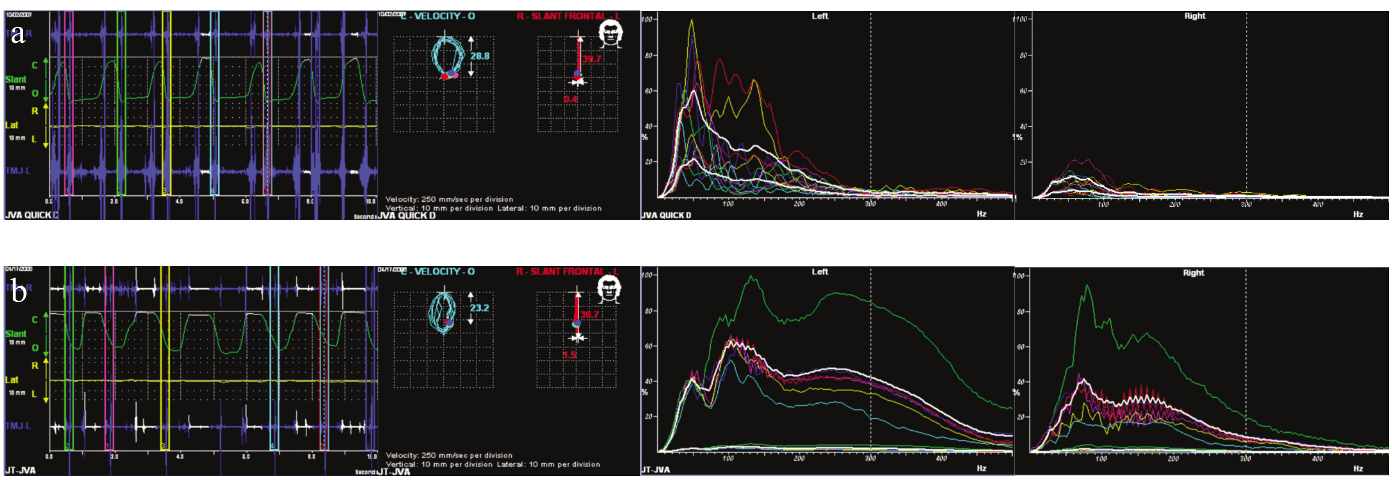

Fig. 3. Subject No. 6 in Group I showed joint sounds on the late opening cycles (before six-months) and the middle opening cycles (after the six-months).
(a); before six-months recordings showed 0.07 and 0.12 integral > 300 /< 300 ratios, repectively. (b); after the six-months recordings showed 0.37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

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 the six-months recordings. While the frequency spectrums showed varied patterns at the different locations that the joint sound occurred before and after the six-months recordings, it would possibly be due to the differences in the degree of internal derangement and/or in the shape of the disc.

CONCLUSIONS

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.

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