

PART I - JOINT VIBRATION ANALYSIS - CLINICAL EFFICACY

- Bessette, R.W.: A Clinical Study of Temporomandibular Joint Vibrations in TMJ Dysfunction Studies. *Presentation - American Academy of Head, Neck Facial Pain, and TMJ Orthopedics. Kansas City, MO. August 15, 1992*

Using Joint Vibration Analysis (JVA), the vibration patterns of 309 joints from 213 patients with clinical symptoms were compared to TMJ arthrography. Of 309 imaged joints, 221 had internal derangement and 88 were arthrographically normal. Results of JVA were also compared with both the patient's and clinician's perception of TMJ sounds.

Joint Vibration Analysis produced sensitivities and specificities of .75 to .95 in distinguishing between normal subjects and those with internal derangement and in distinguishing among various categories of internal derangement.

The use of artificial neural networks to recognize joint vibration patterns will greatly assist the clinician in interpretation of these patterns.

#510

- Brooks, C.P.: Joint Vibration Analysis in 314 Patients Presenting with TM Dysfunction: Correlation with Clinical and Tomographic Data. *Presentation, 8th International Congress, International College of Craniomandibular Orthopedics. Banff, Alberta, Canada, October 1993.*

Three hundred fourteen patients (628 joints) were evaluated using a thorough clinical examination (including auscultation, palpation and doppler ultrasound) and joint vibration analysis (JVA) and compared with parasagittal tomographic survey.

JVA correlation with tomographic findings for various categories of internal derangement was 92.0%. This compared with 43.8% (auscultation) to 49.0% (palpation) for subjective parameters. Joint vibration analysis showed evidence of degenerative changes in 92% of the joints, detectable in only 22.1% by tomographic imaging.

The author concludes that subjective methods have limited usefulness compared with JVA; JVA will detect vibrations associated with degenerative changes earlier than radiographs; and JVA is useful in documenting pre-treatment joint status.

#617

- Brooks, C.P.: Inflammation of the Temporomandibular Joint. *TMDiary*, published by *The American Academy of Head, Neck, Facial Pain and TMJ Orthopedics*. October, 1993

Patients with suspected post trauma joint inflammation or effusion were evaluated with both MRI and joint vibration analysis (JVA).

In 100% of the subjects, JVA showed a characteristic low amplitude, low frequency (0-25 Hz) vibration immediately before mandibular movement.

After trauma, the retrodiscal tissue are frequently compressed at maximum intercuspatation due to articulating disc displacement and resulting condylar distillization. Condylar distillization is aggravated by (traumatic) contracture and spasm of the primary and accessory muscles of mastication. Decompression occurs as the elevator muscles of the mandible relax immediately prior to activation of the depressor muscles. **Abnormal fluid associated with inflammation shifts during this decompression, causing the characteristic joint vibration patterns.**

#417

- Christensen, L.V. and Orloff, J.: Reproducibility of Temporomandibular Joint Vibrations (Electrovibratography). *J Oral Rehab* 1992;19:253-263

Surface electrovibratographic (EVG) recordings were obtained from the temporomandibular joints (TMJ) of clinically normal subjects (absence of TMJ sounds) and clinically abnormal subjects (presence of TMJ sounds). As examined through single factor analyses of variance and coefficients of interclass correlation, the EVG recordings showed excellent reproducibility. The analyses showed also that, **in comparison with clinically normal TMJs, the vibrations of clinically abnormal TMJs had higher median (+79%) and peak (+137%) frequencies, higher peak amplitudes (+740%), and higher intensities** as expressed through the estimated total energy contents (+1843%) and the integrals (+1215%) of power spectrum density functions.

#416

- Christensen, L.V.: Physics and Sounds Produced by the Temporomandibular Joints (Part II). *J Oral Rehab*, 1992; Volume 19:615-617

This article presents the applied mathematics and physics supporting the electronic recording of solid born vibrations of the TM joint, in contrast with the difficulties of microphone airborne recording. **The vibration patterns found in disc displacement are distinctly different than those recorded for osteoarthritis and other degenerative changes.**

#424

- Christensen, L.V., Donegan S.J., McKay, D.C.: Temporomandibular Joint Vibration Analysis in a Sample of Non-Patients. *J Craniomandib Prac*, 1992, Vol. 10; 35-41

In a sample of 20 non-patients, 60% of the subjects had an absence of subjective temporomandibular joint (TMJ) complaints (noises/sounds) that agreed with objective joint vibration analyses (electrovibratography). Among the remaining 40% of subjects, **only 50% of the examined joints showed agreement between subjective and objective findings. Subjects appeared to be unable to reliably detect "weak" (early) symptoms of TMJ dysfunction and possibly disease.** As measured through active protrusion and laterotrusion of the mandible, the guidance angles of the anterior teeth could not explain the absence and presence of TMJ vibrations.

#519

- Cox II, L.K., Windecker, I.G., Suzuki, S., Suzuki, S.H., Cox, C.F. (Restorative Research Group, Department of Restorative Dent, UAB-Sch. of Dent., Birmingham, AL). : Correlation of Computerized Technology & Physical TMJ Diagnosis. *Abstract. J Dent Res 74 (IADR Abstracts) June, 1995.*

In a blind study, forty-five symptomatic patients were evaluated by three experienced clinicians using subjective physical evaluation (auscultation/palpation), computerized axiography and electrovibratography (EVG). Conclusions of the study were that accuracy of subjective physical evaluation was less than 40% compared with vibration analysis (95%). **"EVG is an accurate and reproducible means to record and follow TMD patients."**

#517

- Fader, K.W, Grummons, D.C., Maijer, R., Christensen, L.V.: Pressurized Infusion of Hyaluronate for Closed Lock of the Temporomandibular Joint. *J Craniomandib Prac*, 1993, Vol. 11 Number 1; 68-72

A 24 year-old female was diagnosed with right-sided non-reducing TMJ anterior disc displacement, including closed lock. The patient was infused with hyaluronate. It was assumed that fluid would mechanically distend the joint cavity and free any existing adhesions.

Magnetic jaw tracking (EGN) and **electrovibratography**, with a skin contact accelerometer, were **performed upon initial examination and following infusion.** EGN data showed a significant increase in maximum mouth opening range and in opening and closing mandibular velocities after treatment. **Joint Vibration Analysis showed that the "intensity and severity" of the TMJ vibrations decreased considerably.**

#501

- Ishigaki, I., Bessette, R.W., Maruyama, T.: A Clinical Study of Temporomandibular Joint Vibrations in TMJ Dysfunction Patients. *J Craniomandib Prac*, 1993, Vol. 11 Number 1; 7-13

The vibrations of 221 internal derangements and 88 arthrographically normal joints were compared, using electrovibratography (EVG). Parameters evaluated were total power density, and power density at different frequency ranges.

Power density in the ID patients was significantly greater at each frequency range than the normal controls. When using this parameter, **the sensitivity and specificity of EVG were 75% and 77% respectively.**

#502

- Ishigaki, I., Bessette, R.W., Maruyama, T.: Vibration of the Temporomandibular Joints With Normal Radiographic Findings: Comparison Between Asymptomatic Volunteers and Symptomatic Patients. *J Craniomandib Prac*, 1993, Vol. 11 Number 2; 88-94

Based on a threshold of total vibration energy in 221 arthrographically verified internal derangements, **diagnostic sensitivity for EVG was 82.4%**. At the same time, **98.3% of the asymptomatic control group had vibration energy below this threshold.**

#504

- Ishigaki, S., Bessette, R.W., Maruyama, T. Vibration Analysis of the Temporomandibular Joints with Meniscal Displacement With and Without Reduction. *J Craniomandib Prac*, 1993, Vol. 11 Number 3; 192-201.

The vibration profiles of 102 joints with meniscal displacement with early or late reduction (DDR) and 70 joints without reduction (DD) were compared to arthrographically normal but symptomatic joints.

Diagnostic sensitivity of joint vibration analysis was 96.6% for MDR-early, 91.8% for MDR-late and 77.8% for MD-incomplete. Sensitivity for MD-complete was 57.4% and excluded any consideration of restricted ROM.

#507

- Ishigaki, S., Bessette, R.W., Maruyama, T. Vibration Analysis of the Temporomandibular Joints with Degenerative Joint Disease. *J Craniomandib Prac*, 1993, Vol. 11 Number 4; 276-283.

Surface vibrations of 42 TM joints with degenerative joint disease (DJD) and/or perforation of the disc were evaluated and compared with symptomatic controls (N=83) and 61 joints with meniscal displacement (MD-complete).

TMJs with DJD showed higher vibration energy above 350-450 Hz while TMJs with perforations showed higher vibration energy between 100-150 and 300-450 Hz. Joint diagnosis was confirmed through arthrography and video fluoroscopy.

In addition to differences in frequency patterns, these conditions showed distinctly higher total energy compared with a threshold intensity. Using this threshold, **a significant portion of patients were correctly identified as having internal derangement and/or DJD.**

MD - DJD	100%
MD - Perf.	87.0%
MD-DJD-Perf.	88.9%
Perforations	100%

#518

- Ishigaki, S., Bessette, R.W., Maruyama, T. Diagnostic Ability of the Surface Vibration Analysis of Temporomandibular Joint. *Abstract. IADR. Seattle, WA, March, 1994.*

Vibration patterns from 297 joints from TMD patients were compared with diagnosis by arthroscopy and magnetic resonance imaging. Total vibrational energies were used to discriminate among four specific conditions and showed the following sensitivities: **DDR - 79%; DD - partial reduction - 80%; DD - 77%; DJD and/or perforation - 76%.**

The authors conclude "vibration analysis of the TMJ could be clinically useful as a routine examination for TMD patients."

#520

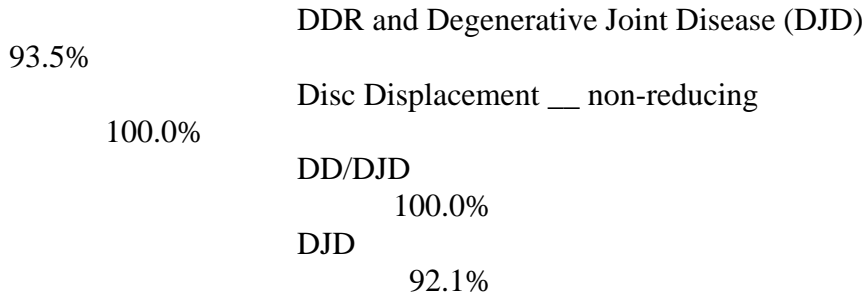
- Knutson, M., Radke, J.: Artificial Neural Network Classification of TMJ Internal Derangement. *Abstract. J Dent Res 74 (AADR Abstracts) March, 1995.*

Three hundred forty-seven patients (462 TM joints) were diagnosed at a multidisciplinary TMJ clinic using comprehensive history, clinical exam, radiologist-interpreted tomograms and Joint Vibration Analysis. These diagnosis were compared with the results of an artificial neural network (ANN) program trained to recognize vibration patterns (The Interpreter^{3/4}).

Of the 227 joints diagnosed with 5 specific pathologic conditions, the ANN (Interpreter) correctly identified 97.0%. Accuracy in identifying specific categories was:

Disc Displacement with Reduction (DDR)

97.6%



Of 224 joints with normal or non-pathologic conditions (disc looseness, eminence click) the ANN (Interpreter) correctly identified 98.2%.

#426

- Radke, J.C., Christensen, L.V.: Artificial Neural Network Classifies TMJ Disk/Condyle Relation From Vibrations. *Abstract. IADR. Glasgow, Scotland, July 1-4, 1992*

An artificial neural network was trained to recognize specific joint vibration patterns. Vibration data from 30 asymptomatic joints and 29 patient joints were input into the network to test its **sensitivity and specificity in distinguishing between normal, displaced disk or reducing displaced disc.** **Sensitivity for displaced disc with and without reduction were .80 and 1.00 respectively. Specificity was 1.00 and .96 respectively.**

The authors conclude that **some differences exist between normal joint vibrations and vibrations resulting from disc disorders.**

#414

- Shiga, H., Akiyama, H., and Kobayashi, Y.: A Quantitative Assessment of Temporomandibular Joint Sound by Spectral Analysis. *11th July, 1989. 3rd ICP (International College of Prosthodontics), Toronto, Canada.*

Joint vibration frequencies were analyzed from 20 controls and 40 patients with craniomandibular disorders. These CMD patients were further segmented into two groups - those with TMJ sound and those without.

The cumulative frequency of the TMJ vibrations showed distinctly different patterns among the three groups.

#508

- Tallents, R.H., et al Temporomandibular Joint Sounds in Asymptomatic Volunteers. *J Prosth Dent, 1993, Volume 69, No. 3; 298-304*

Fifty asymptomatic volunteers (100 joints) were evaluated with SonoPAK for the presence of joint vibration. **Forty-four percent of all joints had identifiable vibrations.** The majority of these vibrations were near the 100 Hz level, while the ear is most sensitive in the 500 to 5,000 Hz range.

The results of the investigation suggest that "when audible joint noises appear, the joint may have been abnormal for some time" and that **"joint abnormalities can exist in asymptomatic patients in the absence of audible joints"**. **Vibration analysis may help identify individuals at risk who may at a later date have pain and dysfunction.**

- Tanzilli, R.A., et al.: Temporomandibular Joint Sounds in Symptomatic Patients. *Abstract. Farrar Norgaard Society Annual Conference, Rochester, NY, August 1, 1992*

Using SonoPAK to evaluate vibration frequency in different internal TM joint pathologies, **joints with DD and DJD demonstrated 200 to 400% more high energy (over 300 Hz.) vibrations than other diagnostic groups. Joint vibration analysis is more sensitive to lower frequencies often not detectable by auscultation or palpation.** SonoPAK detected 6-15% more joint sounds than the clinical examiner.

Evaluation of the frequency spectrum alone, without other vibration and clinical parameters, such as ROM, is insufficient to discriminate between internal joint pathologies.

#423

- Widmalm, S., Westesson, P., Brooks, S.L., Hatala, M.P., Paesani, D.: Temporomandibular Joint Sounds: Correlation to Joint Structure in Fresh Autopsy Specimens. *Am J Orthod Dentofac Orthop, 1992; 101, 60-69*

Joint vibrations from 27 fresh autopsy specimens were recorded with accelerometers, recording the time frequency distribution of the sound and correlating sound character to morphological observations at dissection. While the sample was too small for a statistically significant association, a high frequency vibration component appeared to be associated with arthrosis of the articular surfaces.

The authors concluded that electronic recording of joint vibrations offer several advantages over auscultation and palpitation such as:

- The ability to store and compare observations at different times.
- To record frequency sound and vibrations that would not be perceived by the human ear.
- To eliminate differences resulting from differences in hearing and perception of the viewer.
- To make objective documentation of the sound and its character.

- The ability to analyze the vibration with respect to amplitude energy content and frequency distribution.

#503

- Williams, W.B., Brooks, C.P.: Correlation of TMJ Sonographic Analysis With Clinical and Tomographic Data in 52 Craniofacial Pain Patients. *Anthology of Craniomandib Orth Vol II, 1992; 215-224*

Joint vibration profiles using the SonoPAK were compared with tomographic interpretation in maximally closed and fully open position in 104 joints, in symptomatic patients.

Tomographic interpretation disclosed that 97 (93.3%) of these joints showed non-standard non-symmetrical radiographic condylar position. **Joint vibration showed a high correlation to tomographic indicators, showing abnormal frequency and time domain profiles in 95 or 91.3% of the non-symmetrical joints.**

The authors conclude that simultaneous bilateral **TM joint vibration analysis** is a "useful clinical tool to evaluate, diagnose and monitor progress in craniomandibular therapy".