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RESEARCH ARTICLE

APPLICATION OF JOINT VIBRATION ANALYSIS IN TMJ DISORDERS AND OCCLUSION

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ABSTRACT

With the advent of digital technologies in Prosthodontics, the use of newer technologies must be used to aid the clinician in more objective methods than subjective methods. Clinician must rely on more than subjective findings (e.g. palpation and auscultation) when evaluating the temporomandibular joint. We need a way to objectively assess patient's joint health and document both the pre-treatment conditions and the response to the treatments we provide. Use of Pre - treatment evaluation by Joint Vibration Analysis (JVA), helps in determining the presence or absence of joint pathologies before changes are made to the stomatognathic system. A post treatment evaluation will further aid in knowing the deleterious effects of the treatment procedures on the joint and suitable corrections can be initiated before permanent damage occur. The existence of this type of evaluation of the TMJ in function is critical for objective, diagnostically driven treatment. This article will describe the application of Joint Vibration Analysis in understanding the TMJ disorders and the role of DVA in occlusion.

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INTRODUCTION

The past attempts to record and/or measure the condylar position and condition included axiopath recordings of joint position and border movements, transcranial and tomographic radiography with objective and subjective interpretation, comparison of condylar position on articulators with multiple jaw position "bite" recordings, magnetic resonance imaging (MRI) and functional MRI scans, computed tomography (CT) and cone beam CT scans, contrast arthrography, computerized mandibular positions based on transcutaneous electrical nerve stimulation pulsed muscle contractions irrespective of the condylar position, face-bow mounted casts on various articulators referenced to numerous closure paths from speech to swallowing, from controlled manipulation to deprogrammed patient closure. At best, these methods were expensive and time consuming; and at worst, these techniques were dependent on the clinician's experience and subjective analysis. The current biometric standard with the Joint Vibration Analysis (JVA), allows the Prosthodontist to easily and objectively measure the condition of the condyles quickly, affordably, and irrespective of treatment "philosophy." The JVA system achieves this standard and creates a 21st-century documentation of objective information that will afford the treating dentist the ability to diagnose the patient's condition and monitor the patient throughout preventive or therapeutic care. By establishing objective measurements of the condylar condition, the dentist can evaluate the effect of future events such as injury, accident, or therapy. The doctor can also begin to correlate the condylar condition with other data, such as bite force analysis (with T-Scan) and/or electromyography measurements of the muscles of mastication. In addition this JVA system can be overlaid on data regarding mastication analysis, range of motion, and mandibular position. Joint Vibration Analysis (JVA) is based on simple principles of motion and friction: When smooth surfaces rub together, little friction is created and thus little vibration. However, if surfaces become rough, then friction causes vibrations when these surfaces articulate. The TMJ is a ginglymo-arthroidial joint with surfaces that glide together in function. The smooth, well-lubricated surfaces in a healthy joint have a biomechanical relationship that produces very little friction and almost no vibration. Surface changes, such as those caused by subtle degenerations, any perforations or mechanical displacements generally produce friction and some vibration. Different disorders produce different vibration patterns or "signatures". Joint Vibration Analysis helps the clinician identify these conditions from the vibration patterns and helps distinguish a primary TMJ dysfunction from other painful conditions. When we hear sounds, we distinguish one sound (vibration) from

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another by their differing amplitudes (loudness), durations (long vs. short sounds) and pitch, harmonics, etc. (sound qualities). JVA does the same thing, but more accurately, without any subjectivity, with honest reproducibility and providing a permanent record that is available for valid comparisons in the future. JVA is a diagnostic aid used to measure how the patient's joints are functioning before starting any case that repositions the mandible. In less than 5 minutes, one can provide a highly accurate, quantitative test analyzing the stability and function of the Temporomandibular Joint. Joint Vibration Analysis is a quick, non-invasive method for objectively evaluating the Temporomandibular Joints. Much like the way one evaluate the wear on the teeth, JVA enables the dentist to get a sneak peek into the health of the jaw joint before, during and after the Prosthodontic treatment (Nandeeshwar *et al.,* 2015).

The prevalence of sounds in the population is variable, occurring in 21.5% (Ciancaglini *et al.,* 1999) to 86% (Garcia *et al.,* 1988), and appears to depend on the group of individuals studied. It may even be found in young adults, and in some cases indicates vibrations produced by movement of the synovial fluid (Olivieri *et al.,* 1999) or precocious TMJ disorders due to systemic alterations (Widmalm *et al.,* 2006). Joint overloading that occurs after losing the back teeth, or the habit of teeth clenching or grinding may alter the lubrication mechanism and increase attrition between the joint structures, as observed by Nitzan (Nitzan, 2001). The reduction of lubrication and the overloading of joint surfaces increases attrition between the structures and may cause the development of tissue fibrillation (Morel *et al.,* 2006). In addition, it may cause temporary or permanent adhesions of the joint disc. These are some of the causes leading to the alteration of TMJ biomechanics and joint sounds (Okeson, 2000). The effect of overloading the temporomandibular joint seems to be more evident after the loss of posterior teeth, and is more significant in older patients, particularly patients with arthritis whose most common joint characteristic is crepitation (Christensen *et al.,* 1986). It was also found that joint vibration is more frequent at the end of mouth opening and closing in partially edentulous patients, and that vibration is significantly reduced after the second year of occlusal treatment (Baleeiro *et al.,* 2006). In view of the fact that according to the literature, occlusion seems to be related to joint sounds. Identifying the characteristics of joint sounds in certain occlusal patterns or dental arch configurations may contribute towards the diagnosis of certain joint pathologies (Alício Rosalino Garcia *et al.,* 2008).

Principle of JVA

Are vibrations and sound the same? Yes and No. All audible sounds come from vibrations, but not all vibrations produce an audible sound. In fact, our ears are simply incapable of hearing joint vibrations at the low frequencies that some important joint pathology produces. We may also be confused by the combined sounds of two conditions present in the same joint or the side it's on. This is probably why research studies show that auscultation has about the same accuracy as random chance (Eriksson *et al.,* 1987; Paesani *et al.,* 1992; Hardison *et al.,* 1990; de Wujen *et al.,* 1995). Furthermore, ears (and microphones, incidentally) pick up room sound and other artifacts, where JVA picks up only vibrations from the joint itself.

JVA as a process

The process of JVA is initiated by recording bilaterally the vibration waveforms in the time domain. This provides the measures of amplitude and duration. Next, an FFT (fast Fourier transform: Fourier analysis converts a signal from its original domain (often time or space) to a representation in the frequency domain and vice versa.) is calculated, which supplies the indications of pitch and harmonics. What becomes evident to the practitioner is that each TM joint condition is accompanied by a specific combination of amplitude, duration and frequency characteristics. Joint Vibration Analysis (JVA) uses tissue accelerometers to objectively capture vibrations given off by structurally compromised internal TM Joint anatomy. The structural breakdown leads to altered mandibular movement patterns during chewing function. Different attributes of representative JVA vibrations have been shown to indicate the presence of various disease states often seen within the Temporomandibular Joint complex. After being recorded, the JVA software displays the various vibration waveforms for clinician analysis to determine the specific internal derangement present. Traditionally, we have used palpation and auscultation to detect TM joint "sounds". Auscultation is dependent upon the hearing ability of the examiner and is limited to unilateral testing with no permanent record. The interpretation of these "sounds" has been shown to be very difficult — "What type of sound was it?" — "Did it occur upon every opening?" "Which side did the sound occur on?" Palpation is a skill with a steep learning curve that requires great tactile sensitivity and suffers from a low specificity. Even though it is usually done bilaterally, it can be very difficult to distinguish which side is causing the joint sound (Widmalm *et al.,* 1999).

JVA, in contrast, is a passive device that;

- Objectively records all of the vibrations of the underlying tissue during function,
- Distinguishes which side the vibration originates on,
- Creates a visual image of the vibration,
- Measures the intensity of the vibration,
- Precisely quantifies the frequency content and
- Provides a permanent record for future comparison.

The test is simple, takes 3 to 5 minutes and is painless. A headset is placed over your head (like a stereo headset) with the vibration sensors on the skin over the TM joint in front of each ear. The subject is asked to open wide and close all the way 5 or 6 times. Now the computer takes over to provide your specific vibration signature to be evaluated, which gives a graphical representation of the sounds and vibrations.

If a TM disorder does exist, the severity can be checked again at the next appointment to see if it is stable, worsening or improving. In fact, "signature" reading may be redone anytime as a guide to assess the treatment outcome.

JVA in Occlusion

Prosthodontists end up discussing the "philosophy" of occlusion without regard to routine objective measurements that could establish the relative health or normality of the stomatognathic system. Common dental treatments can change mandibular position. In addition to TMD treatment, orthodontics, prosthodontics, restorative, and sleep dentistry can all benefit from JVA testing. Patients requiring extensive occlusal construction can be evaluated before the treatment and comparison can be made during the restorative phase, wherein provisional restorations are given and during the construction of final occlusion. In fact pre and post operative evaluation can be done even after a single crown is luted to check for occlusal interferences. During the construction of complete dentures, removable partial dentures too, DVA can be used to check the movement of jaw in maximum intercuspal position and centric relation position.

Conclusion

JVA is not invasive and more accurate (Gallo *et al.,* 2000; Ishigaki *et al.,* 1993; Ishigaki *et al.,* 1993; Olivieri *et al.,* 1999; Radke *et al.,* 2001) than auscultation or palpation with a repeatable permanent record of TM joint function or dysfunction. And, it can be recorded by a staff member in about a minute. JVA is a great screening test since it has such a high specificity (Ishigaki *et al.,* 1993). It is also the ideal, low cost way to monitor joint function during the course of treatment. While it does not eliminate the need for expensive imaging, it allows the practitioner to make a more informed decision whether the cost of imaging is justified.

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