Digital Solutions for Acute Stomatognathic Trauma

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The global positioning system (GPS) has revolutionized the way people travel, whether it is by air, water, or land. This system precisely directs users to their geographic destinations. Developed by Dr. Ivan Getting in conjunction with the US Department of Defense, and launched in 1973, GPS is a network of satellites designed to calculate geographical positions. Modern GPS is accurate, predictable and cost-efficient enough to allow daily use in all forms of travel.[1,2] Today, dentists have a similar advantage, the opportunity for clinical predictability as a result of the advancements in diagnostic and restorative technology.

Acute trauma to the stomatognathic system can be a life-altering episode that modifies the needs of the reparative system. The human body maintains its health and vitality by a continual process of cell turnover that generates homeostasis. Trauma to the stomatognathic system can create an array of symptoms associated with multiple levels and extension of damage. Identifying the source of the symptoms with a rapid and accurate diagnosis, followed by appropriate treatments, is the key to clinical restoration, so that the body can regenerate homeostasis via rapid adaptation.

The stomatognathic system can be classified into three major subsystems based on biomechanical functions:

1. Dentoalveolar complex: acts as the biomechanical lever
2. Temporomandibular joints (TMJs): act as the biomechanical fulcrums
3. Muscles of mastication: provide the energy to power the system

In the dentoalveloar complex, the most common injuries to permanent teeth occur with falls.[3] Among these are a progressively escalating range of injuries, which include crown infraction, uncomplicated and complicated crown fractures, root fractures, concussions, subluxations, lateral luxation, intrusion, extrusion, and avulsion.[4]

If a traumatic episode occurs in the TMJ, it can originate a (or exacerbate an existing) temporomandibular disorder (TMD). This damage can limit the range of motion, with or without concurrent increase in pain. Demographic traits of acute TMD trauma patients reveal a less educated population of young men. They report an initial higher overall rate of symptoms including pain and limitation in motion; however, these are of short duration with a decrease in tenderness to palpation and perceived malocclusion.[5] Even though TMD patients have demonstrated positive results after treatment, a significant percentage of trauma patients have reported using medications at follow up.[6]

Patients reporting pain secondary to trauma require a differential diagnosis of a true intracapsular TMD vs an extracapsular disorder of the stomatognathic system for immediate and long-term clinical management. Myofascial pain associated with trauma can limit the range of motion of the mandible as well. A thorough palpation examination in conjunction with surface electromyographs (EMGs) can aid in the differential diagnosis of acute pain that may be of extracapsular origin from the muscles of mastication.[7] A well documented, comprehensive dentoalveloar, TMJ, and myofascial history and assessment are mandatory for proper treatment planning and delivery of treatment for pain management, and esthetic and functional restoration of the dentition while minimizing negative long-term effects.

Case Study

A 21-year-old woman presented with an acute traumatic episode involving a bicycle accident that caused her to land face first onto a concrete driveway. She reported the inability to sleep all night because of sharp, shooting, radiating pain in the midline of her maxillary left central incisor (tooth No. 9) radiating on the left side of her face up to the eye (Figure1). The traumatic injuries to teeth Nos. 8 and 9 were diagnosed as complicated crown fractures, which by definition include pulpal involvement in the dentoalveolar complex. The condition was diagnosed with the aid of radiographs, pulp vitality tests, and

Figure 1 Preoperative traumatized dentition.

Figure 2 Traumatic fractures of Teeth Nos. 8 and 9.

ultraviolet (UV) transillumination in conjunction with patient history (Figure 2 and Figure 3).

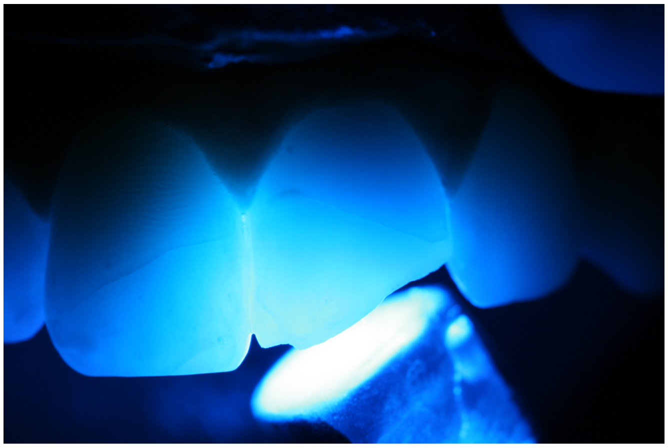

Figure 3 UV transillumination helped diagnose the fractures.

The patient also reported that the blow to the midline of her chin pushed her jaw back. Doppler sonography and range of motion tests were performed to screen the preliminary condition of the TMJs. The results indicated crepitus in the left TMJ with a relatively low range of motion in left lateral movement. Based on the nature of the patient's injuries and the immediate need for pain management and restorative care in the esthetic zone, two separate technologies were used to diagnose and treat the patient: joint vibration analysis (JVA) with the BioJVA™ (BioResearch Associates Inc, Milwaukee, WI)/jaw-tracking range of motion and velocity tests with the JT-3D™ (BioResearch Associates Inc) and CEREC® 3D (Sirona Dental Systems LLC, Charlotte, NC) for single-visit restoration of the fractured teeth.

JVA is based on the principles of friction and motion. Healthy TMJs have smooth, lubricated surfaces in a proper biomechanical relationship and, therefore, produce

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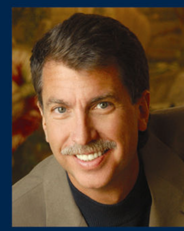

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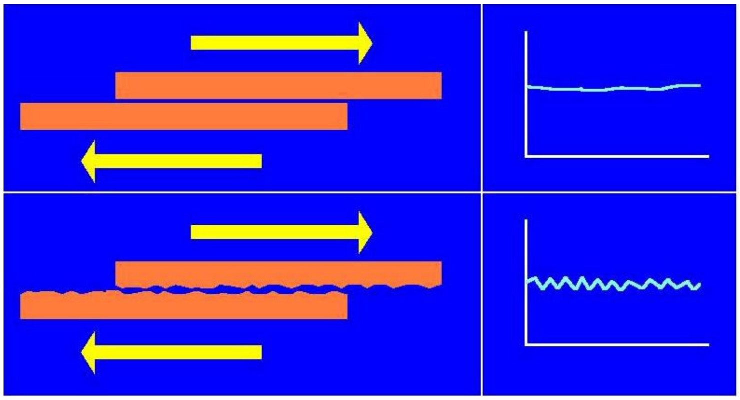

Figure 4 JVA principle of friction and motion: Healthy joints do not produce friction and yield a flat line graph; damaged joints produce friction during motion and yield a graph with vibrations.

little friction and corresponding vibration. TMJ surface changes, caused by tears, displacements of the disk, or degeneration, produce friction and vibration (Figure 4). Different disorders produce different vibration patterns or "signatures."[8-12] Computer-assisted digital vibration analysis recorded by accelerometers, rather than a microphone (sonography), identifies these patterns more accurately and predictably to distinguish among various TMDs.[13-19]

Intuitive software allows interpretation of the BioJVA and JT-3D data in an organized manner for accurate and efficient diagnosis. The record mode yields a raw data screen that consists of five windows: JVA Sweep (upper left window), Narrative (upper right window), Zoomed View (lower left window), Superimposed Vibrations (lower middle window), and Gnathography (lower right window) (Figure 5). Vibrations produced by functional pathologies are recorded in the sweep window and then are marked with a mouse click in the review mode, while monitoring the magnified

Figure 5 BioJVA/JT-3D recording. The record mode yields a raw data screen that consists of five windows: JVA Sweep (upper left window), Narrative (upper right window), Zoomed View (lower left window), Superimposed Vibrations (lower middle window), and Gnathography (lower right window).

vibration for accuracy in the zoomed window. The software automatically calculates the energies of each marked vibration in the narrative window, including the averages of all marked episodes. The wave pattern "signature" of the marked vibrations is interpreted, then verified by mathematical analysis. The superimposed view allows an overlay visualization of each marked vibration to verify the repetitive anatomy of the vibrational waves to validate that the marked episodes are not aberrant or random energies but diagnostic episodes. Gnathography identifies the exact location of the

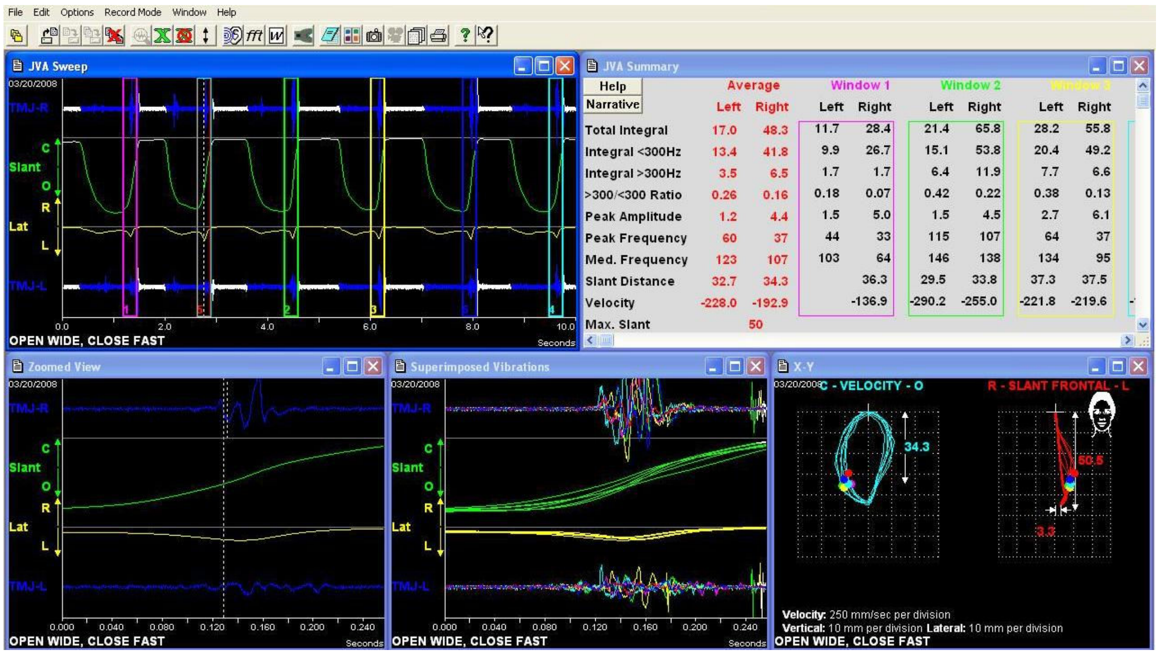

Figure 6 BioJVA/JT-3D recording. Each joint has an independent graph. Vibrations occurring in the opening and closing cycles (blue part of graph) are marked with a mouse click and the location of the episode is calculated automatically in the gnathology window.

episodes during the opening and closing cycles in conjunction with the mandibular path. (Figure 6). In this case, the gnathography window demonstrated a deviation of the mandible to the left with repetitive episodes at 34.3 mm in the closing cycle with the patient partially displacing the disc in the right TMJ. Next the frequency spectrum of the marked episodes is studied to differentiate between hard-tissue and soft-tissue damage within each joint based on the knowledge that soft-tissue damage yields high-amplitude low-frequency waves (< 300 Hz) while bony changes yield low-amplitude

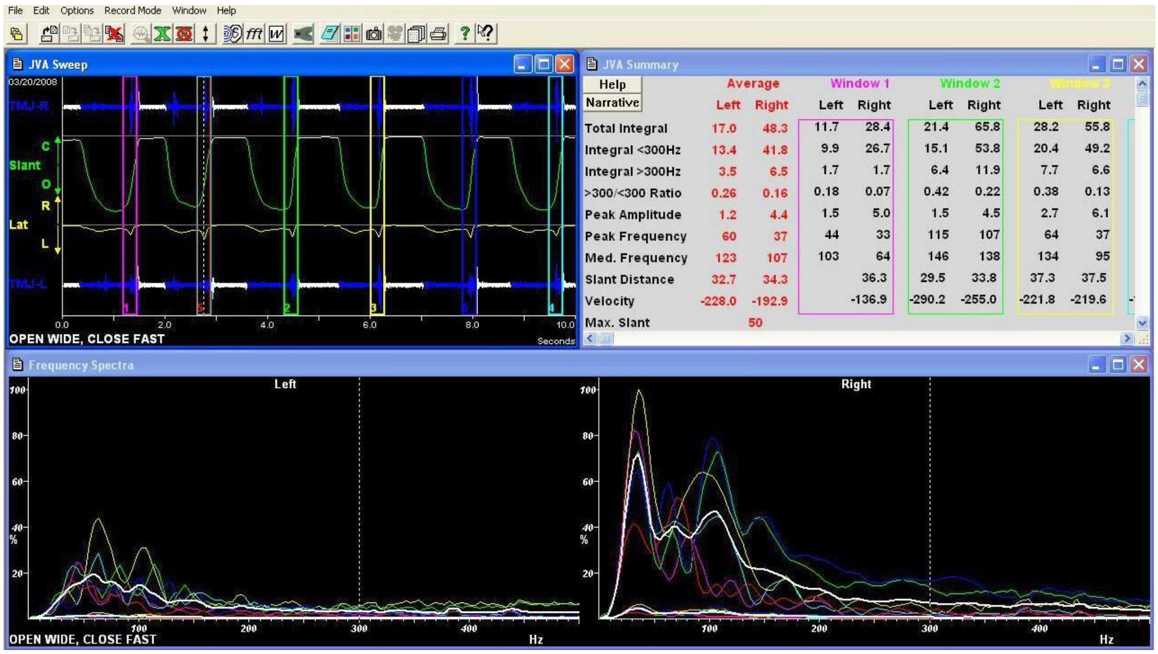

Figure 7 BioJVA/JT-3D. The frequency spectrum of the marked episodes is studied to differentiate between hard-tissue and soft-tissue damage within each joint based on the knowledge that soft-tissue damage yields high-amplitude low-frequency waves (< 300 Hz) while bony changes yield low-amplitude high-frequency waves (> 300 Hz).

high-frequency waves (> 300 Hz) (Figure 7). The frequency spectrum showed significant and repetitive waves of high amplitude and low frequency (< 300 Hz) in the right TMJ, further confirming soft-tissue damage. Finally, the wavelet transform view provides a 3D visualization of the marked episodes and the records frictional energy being generated during the disc displacing episode for easy interpretation and ease of patient explanation of the diagnosis (Figure 8). The patient received a working diagnosis of the right TMJ indicative of a partially displacing disc with reduction and

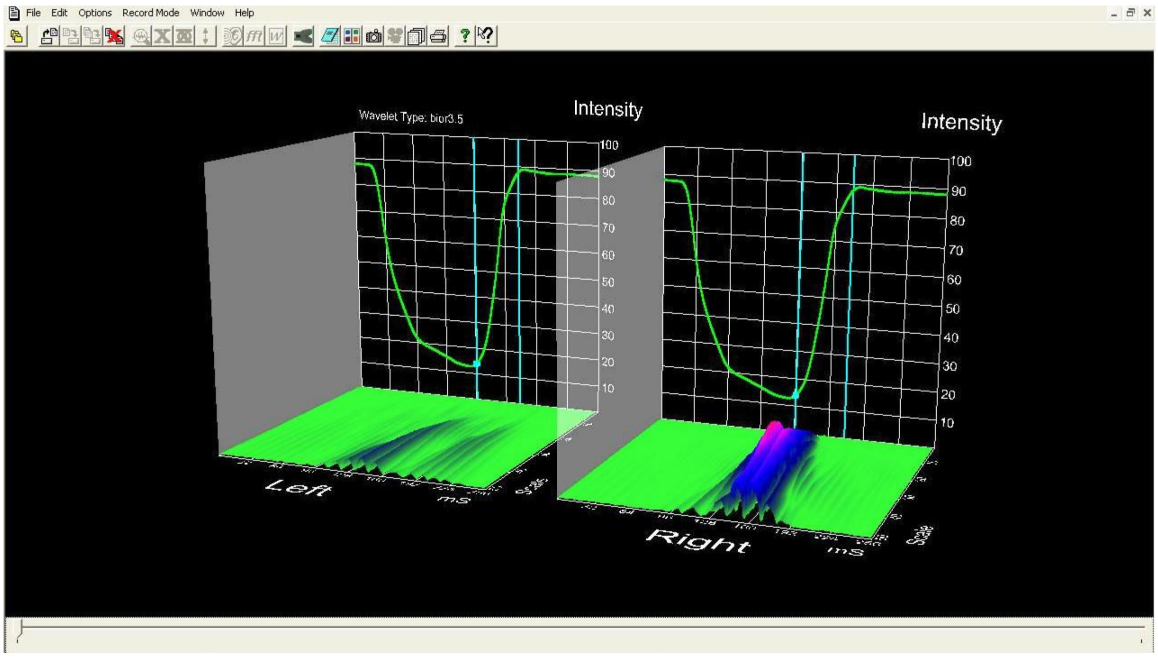

Figure 8 BioJVA/JT-3D. The wavelet transform view provides a 3D visualization of the marked episodes and the recorded frictional energy being generated during the episode for easy interpretation and patient explanation of the diagnosis.

left TMJ indicative of ligament laxity.

The working diagnosis resulted in a treatment plan consisting of phased therapy. Phase 1 treatment in the dentolavelolar complex consisted of endodontic therapy on teeth Nos. 8 and 9 to be followed by in-office CAD/CAM restorations for the traumatic damage in the esthetic zone. Phase 1 therapy for TMD and myofascial pain was prescribed simultaneously and included occlusal orthotics, follow-up reevaluations to monitor patient symptoms and changes in range of motion as well as T-Scan III assisted occlusal equilibrations. Phase 2 comprehensive restorative care for the remainder of the nonemergency dental maladies would be performed after completion of Phase 1 therapy to resolve acute symptoms with a verification of functional stability of the TMJs via a follow-up BioJVA with JT-3D analysis. After completion of Phase 2 therapy, occlusal stability would be monitored via T-Scan III technology while TMJ stability is being monitored with BioJVA and JT-3D with long-term management of parafunctional habits via appliance therapy.

In Phase 1, after completion of endodontic therapy, D.T. Light-Posts® (Bisco, Inc, Schaumburg, IL) with composite core buildups were used as the foundation for the crown preparations because they meet the functional and esthetic criteria for all-ceramic CAD/CAM crowns (Figure 9). With the CEREC 3D system, Sirona Dental Systems has innovated the process[20] that

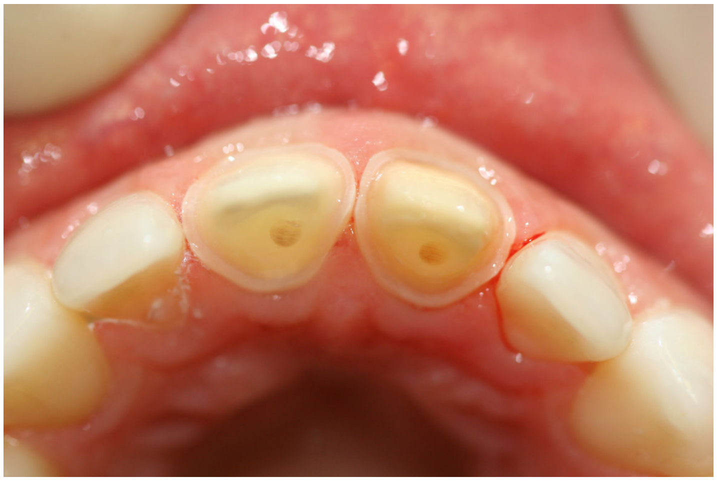

Figure 9 Teeth Nos. 8 and 9 prepared for CAD/CAM all-ceramic crowns.

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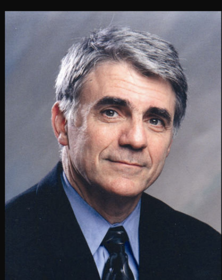
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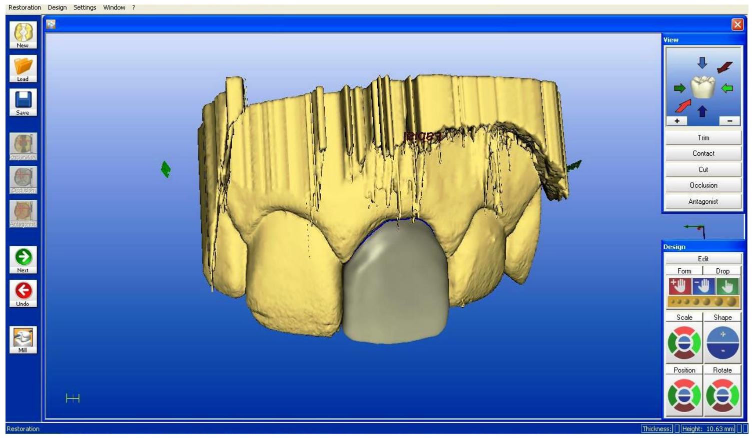

Figure 10 Tooth No. 9 designed and replicated from tooth No. 8.

Figure 11 Final cemented crowns.

Vitablocs® Mark II TriLuxe shade IM2C all-ceramic material (Vident, Brea, CA) was used for fabrication of the crowns. Intraoral try-in was accomplished to verify marginal adaptation, shade, and final contours. The milled all-ceramic restorations were glazed,[31] in 6 minutes using the Vita Akzent Stain and Glaze Kit (Vident) and a programmable porcelain furnace.The glazed restorations were cemented with Variolink® II (Ivoclar Vivadent, Inc, Amherst, NY) cement (Figure 12).

Figure 12 Close-up of glazed and cemented restorations.

Conclusion

Management of acute trauma often has been empirical, based on the in-office technologies available to the general dental practice. In the era of GPS travel, integration of BioJVA/JT-3D and CEREC 3D technologies offer dentists the opportunity to arrive at the goal of healing the patient's stomatognathic system from acute trauma accurately and predictably, with beautiful smiles in record time (Figure 13). This is truly the age of evidence-based dentistry; BioJVA/JT-3D and CEREC 3D are vital components of the clinician's armamentarium.

Figure 13 Postoperative restored dentition.

Disclosure

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