COMPUTER GUIDED OCCLUSION
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Occlusion has become one of the most highly debated concepts in dentistry. Most clinicians believe that balanced occlusion is critical in the preservation of Dentistry. Yet, how do we know what balanced occlusion means? Many believe this is determined by marking teeth with paper, which is the traditional method. There is no research published that confirms the inks in paper do anything but mark tooth location.

Articulation paper marks give an endpoint stamp of tooth contact order; actual contact sequence cannot be determined from paper. There is no scientific correlation between the depth of the color and the mark, its surface area, amount of time, or force that results as that paper mark is made. As evidenced in research, articulating paper only provides tooth locations; it cannot display time or force.

Articulating Paper Misconceptions

Identifying occlusal contacts with articulating paper/ribbon marks is believed to illustrate the nature of the timing and occlusal force that is contained within the markings. The depth of color and the surface area of the occlusal markings are perceived by the clinician to describe the contact force.

However, articulating paper marking materials have many limitations. Studies by Schelb et al[1], Halperin et al[2], and Mori et al[3] describe paper thickness, marking ability and material types. But there are no studies in dental literature that suggest articulating paper can measure occlusal contact time or force data. In short, "*Paper is just Paper*" and paper is not capable of measuring time and force.

Articulating paper can give occlusal contact location information only. It is incapable of measuring timing sequence, occlusal force, and pressure. Therefore its appearance should not be judged for the quality of the occlusal design.

Occlusal Balancing

Bilateral contact simultaneity[4] requires that all teeth on both halves of the arch occlude in less than .2 seconds from first to last contact. Bilateral simultaneity can only be clinically established through measurement and adjustment of the actual occlusal contact sequence. This ensures no single dental arch area occludes early and is forced to absorb excess stress.

The following case describes the inability of articulating paper to describe the forces contained within the paper marks.

Figure 1a – "Paper only" anterior adjusted result

Figure 1b – "Paper only' posterior result

Figures 1a and 1b show the paper occlusal result. The marks are widespread and fairly uniform. However, because articulating paper has no occlusal time or force measurement capacity, the clinician has no clear understanding of whether the occlusal design is physiologic or unbalanced.

The only way to precisely measure occlusal forces and time is with the *T-Scan* III, a Computerized Occlusal Analysis system. *T-Scan III* utilizes an ultra-thin, reusable sensor, shaped to fit the dental arch which inserts into data acquisition electronics (Figure 4). This system is portable and plugs into the USB port of your Windows based PC or laptop. Analyzing vivid graphics makes the balance of the perfect bite easy to determine and adjust. The recording sensor prevents the "hit or miss" interpretation of colored ink marks on teeth by the clinician.

The inability of articulating paper to formulate measurements can be seen in Figure 2. The *T-Scan* III force plot shows the occlusal forces are mostly on the right half of the arch, indicating non-simultaneity to the total contact sequence of the paper only result. This non-simultaneous contact pattern exhibits much higher total force on the right half of the arch (62% right to 38% left).

By refining this poorly designed, paper only resultant force pattern with the *T-Scan* III, the end result in Figure 3 illustrates near perfect force balance. The after plot shows a bilaterally simultaneous occlusal design, as the forces are centered all through the contact order and there is nearly equal force concentration on both arch halves.

Figure 2 – Paper Only Result

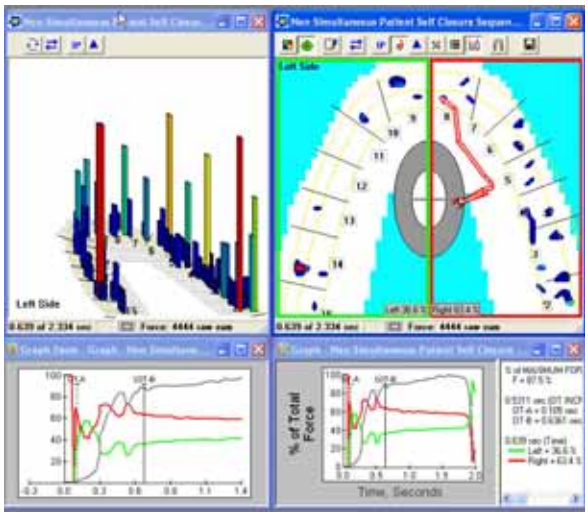
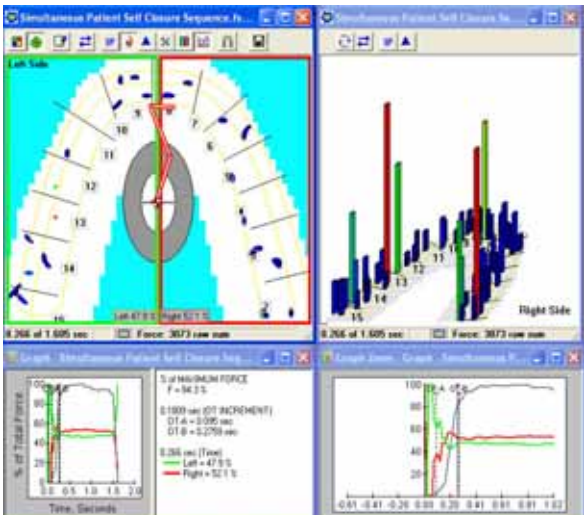


Figure 3 - *T-Scan* III Computer Guided



This same principle can be applied in any clinical situation from occlusal diagnosis to delivering dental prostheses. It is possible to make measured assessments followed by measured occlusal timing and force adjustments to any prosthesis or natural tooth scenario to improve patient prosthesis occlusal acceptance, and reduce MPDS symptoms and occlusal discomfort. Precise occlusal endpoints are readily attainable when corrections are guided by the *T-Scan* III system.

Technology That Quantifies Time and Force for Precise Occlusal Adjustment

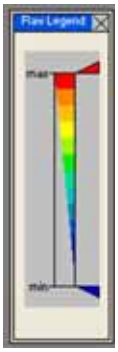
Figure 4 – *T-Scan* III

As a patient occludes onto the T-Scan sensor (Figure 5), the applied force at various tooth contacts changes over time. Occlusal contacts are recorded and then displayed in two and three dimensions as a continuous force "movie" of the entire occlusal contact event. The movie can be recorded and saved into a patient database for later viewing.

Figure 5

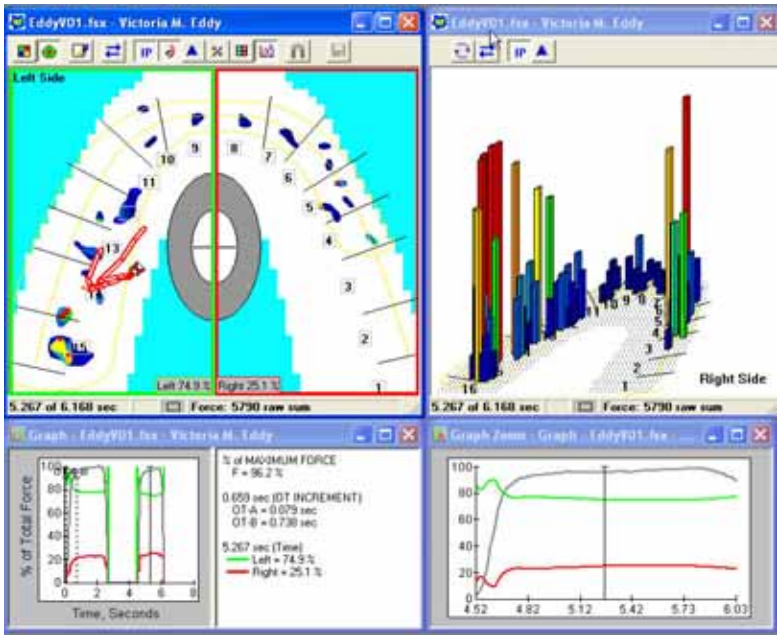
The recorded Force Movie[6] illustrates the occlusal contact timing sequence and force in colors. The darker, cooler colors represent low occlusal pressure gradients whereas the brighter, warmer colors indicate higher occlusal contact pressures (Figure 6).

Figure 6 – Relative Force Legend



In 2 or 3 dimensions, the contact timing sequence can be played forward or backward continuously, or in .01-second increments, to reveal the changing occlusal conditions. In 3 -D playback view, the force columns change both their height and color designation. In the 2-D contour view, the color-coded force concentration zones change size, shape and color as occlusal forces change (Figure 7). The 2-D contour view closely resembles the articulation paper marks.

Figure 7



Occlusal Examination

The *T-Scan* III system can be used in a clinical occlusal examination to assess various occlusal time and force parameters that can often be correlated to evidence of occlusal force arch half imbalances[4], occlusal contact timing non-simultaneity[4], Centric Relation prematurity determination[7], and prolonged posterior disclusion[8,9,10]. The timing and force analyses can often be correlated to MPDS symptomotology,[8,9,10] occlusal wear, abfraction formation, periodontal tissue loss, cracks and craze lines in enamel, and tooth mobility[11].

A *T-Scan* exam consists of recording a series of Force Movies for each patient that, when reviewed, reveal the presence of these occlusal timing and force aberrations. The *T-Scan* III examination recordings are:

1. **Centric Relation Recording[4]** – This recording obtains the first premature tooth contact in Centric Relation.

2. **Patient Self-Closure into Maximum Intercuspation** – This recording determines the right to left arch force percentage imbalance and the **Occlusion Time**[3] (time it takes for the patient to reach complete intercuspation).

3. **Excursive Movement Recording** – These right, left, and protrusive excursive movement recordings illustrate anterior guidance effectiveness (or lack thereof) as measured by posterior **Disclusion Time**[8] (which is the elapsed length of time for working, non-

working, and protrusive interferences that precede total guidance control by the anterior teeth).

4. **Habitual Force Pattern (HFP[11]) Recording** – A Habitual Force Pattern is captured by recording the patient swallowing, squeezing and firmly tapping their teeth together repeatedly on a recording sensor. These movies illustrate which teeth are early, repetitive, and overloaded in the patient's chewing cycle.

Clinical Applications of the *T-Scan* III System

Natural Tooth adjustment procedures such as Occlusal Equilibration and Disclusion Time Reduction, as well as all forms of dental prosthesis insertions (Fixed Prosthodontics, Removable Prosthodontics, Implant Prosthodontics, and combinations of these) can be guided by the *T-Scan* III system so that known occlusal timing and force balance endpoints are achieved.

T-Scan analysis can be used in numerous clinical applications, including but not limited to:[4-14]:

- Understanding the timing sequences and forces which are poorly represented by all forms of articulating paper markings
- Occlusal Equilibration endpoint control
- TMD splint/orthotic occlusal force balancing and centering
- Isolating painful teeth caused by Occlusion
- Crown and Bridge, Adhesive, Complete, and Partial Prosthodontic case finishing at prosthesis insertion
- Provisional Occlusal design evaluation
- Disclusion Time Reduction Therapy /Enhanced Computer Guided Anterior Guidance
- Implant supported prosthesis occlusal force control
- Implant Time Delay
- Long term record of patient occlusal histories
- Legal documentation of treatment results

Occlusal adjustment procedures performed upon non-restored natural teeth, restored natural teeth, differing dental prostheses, and implant supported prostheses can be guided by computer analysis to accomplish precise, ideal, measurable occlusal endpoints[4,8,12,13].

By viewing the recorded *T-Scan* III time and force data, and correlating that to the locations (only) of articulating paper marks, the sequence of contacts and the forces contained within each labeling can be visualized and interpreted. Corrective occlusal adjustments can then be made to natural teeth, dental prostheses and implant prostheses, with knowledge of the order and force content within a specific mark (or a series of marks). Occlusal force control on dental materials, dental implants, and/or natural teeth can then be measurably designed to ensure material, implant, or occlusal surface survival.

Summary

As evidenced in research, articulating paper only provides tooth locations, unlike the *T-Scan* III System. The precise technology of the T-Scan III, analyzes occlusal contact force and time sequences and quickly isolates excessive force concentrations and prematurities for predictable and effective treatment. Computer guided occlusal adjustments ensure improved force and time dynamics to balance and better adjust natural teeth and/or install a variety of dental and implant prostheses.

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1. The most current version of the *T-Scan* system that is in use clinically today is:
    a) *T-Scan* I
    b) *T-Scan* II
    c) *T-Scan* III
    d) *T-Scan* IV

2. Articulation paper marks indicates the following:
    a) occlusal force
    b) contact sequence
    c) tooth location only
    d) none of the above

3. When the *T-Scan* III sensor is squeezed between a patients' teeth, the recorded data describes:
    a) occlusal contact time sequencing
    b) occlusal contact force analysis
    c) occlusal contact pressure gradients
    d) paper mark quality
    e) all of the above
    f) none of the above

4. A recorded Force Movie describes the occlusal pressures:
    a) in lb/in^2
    b) in colors
    c) in mPa
    d) in N/cm^2

5. The *T-Scan* III system can be used clinically:
    a) for diagnosis of occlusal problems
    b) to precisely install dental prostheses
    c) to treat occlusal symptoms from MPDS syndrome
    d) to locate and eradicate occlusally active painful teeth
    e) all of the above
    f) none of the above

6. Real-time occlusal contact event recording is accomplished by the *T-Scan* III system in:
    a) 1.0 second increments
    b) 0.1 second increments

c) 10 second increments
d) .001 second increments

7. Bilateral contact simultaneity implies
   a) all teeth on 1 side of the arch meet before the other in >.2 seconds
   b) all teeth in the anterior half of the arch meet in <.2 seconds before the posterior teeth
   c) all occluding teeth on both halves of the arch occlude in > .2 seconds from first to last contact
   d) ensures no one region of the dental arch contacts too early or too late

8. Articulating paper marking size and depth of color indicate:
   a) occlusal contact force information
   b) occlusal contact pressure information
   c) occlusal contact timing sequence information
   d) occlusal pattern quality
   e) all of the above
   f) none of the above

9. *T-Scan* III guided occlusal adjustments:
   a) can be employed with removable dental prosthesis insertions
   b) can be employed with natural tooth adjustment procedures
   c) can be employed with dental implant prosthesis insertions
   d) can be employed with fixed Prosthodontic occlusal adjustments
   e) all of the above
   f) none of the above

10. The *T-Scan* III system simplifies occlusal analysis because:
    a) It records occlusal information in fractions of minutes
    b) It provides the clinician with static occlusal contact information
    c) It quickly isolates excessive force concentrations and time premature contacts so that their eradication becomes predictable and effective
    d) It is faster to record occlusal data than it is to mark the teeth with articulating paper

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