

## Occlusion

# A review of: "Comparison between conventional and computerized methods in the assessment of an occlusal scheme."

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## Advanced Dental Technologies & Techniques

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Drs. Dias, Rodrigues, Messias, Guerra, and Manfredini, are to be noted for their efforts in attempting to correlate Articulating Paper Markings, Optical Scanning, and T-Scan force data to each other. The authors reported a weak correlation existed between articulating paper mark area, optical scanning and T-Scan force output. The findings of a weak correlation make sense because the authors were actually comparing "apples to oranges" within their method, because the T-Scan measures occlusal force levels as they spread out from a contact, while articulating paper illustrates contact area, dependent upon the thickness of the paper (media). The authors' speculation T-scan sensor thickness may be problematic and their conclusion; "...relying on articulation foils to evaluate occlusal contacts may still be viewed as the best available clinical method," is completely without any other reliable scientific support within the entire dental literature.

## BACKGROUND

Force spread will always be larger than the contact area, as forces travel along opposing cuspal inclines, down into fossae, and across marginal ridges away from the point of contact. By not explaining this difference to an unknowing reader, the authors portray the paper mark method as being reliable and useful while discounting that the other two methods do not improve on the paper mark method in any way. They then reach a conclusion that "the conventional method may be enough for most clinical purposes," which is completely false based upon the several existing paper mark studies that the authors alluded to, but have not accurately characterized in their literature review.<sup>1-3</sup> The authors left out of their review several additional studies that clearly show the inability of the paper mark force interpretation method to describe occlusal force levels.<sup>4-6</sup>

Of importance to the reader, despite being omitted from this article, is the fact that the T-Scan occlusal force and timing data has been very well documented in many previously published human occlusal adjustment studies since the early 1990s. T-Scan has been found to be very useful, both in treating natural teeth and for improving human chewing function and in reducing the symptoms of TMD.<sup>7-19</sup>

The conventional method alone cannot match the occlusal adjustment endpoints of a computer-guided adjustment procedure,<sup>5</sup> indicating that the conventional method is definitely not "enough for most clinical purposes." Unfortunately, the authors appear to be biased in favor of the outdated and proven inaccurate method of subjectively interpreting the forces associated with articulating paper markings. Their conclusion suggests that patients don't really benefit from precise, measured occlusal force T-Scan

guided corrections, but in fact, many studies do show that patients do markedly benefit.<sup>7-19</sup> This is understandable considering the authors did not apply any precise occlusal force guided corrections or actually use the T-Scan to evaluate the subjects' occlusions. They only compared the T-Scan force distribution measurements of the patients biting on a flat appliance to the estimated high or low intensities visually interpreted from just the paper marks. Assuming that the paper mark estimates are correct and the T-Scan measurements are somehow wrong is not a scientific approach to this comparison. Without ever actually applying the method of Immediate Complete Anterior Guidance Development (ICAGD) by using the T-Scan, it is impossible for any clinician to realize the extent of that benefit to patients.

To bolster their position that subjectively interpreting the appearance characteristics of paper markings is a valid and adequate method, the authors make a number of incorrect statements (outlined below in detail), that are written as being "fact", despite that they are actually only the authors' opinions. Many of these stated opinions have already been proven to be incorrect in the previously published measured occlusion research and scientific literature, that the authors omitted from their review, perhaps because these studies' conclusions contradict the authors' biased opinions.<sup>4-19</sup> By publishing an article appearing to review T-Scan in which the authors have excluded many Disclusion Time Reduction (DTR) studies that have been in the dental literature since 1991, the journal denies the reader an opportunity to learn about a scientifically validated measured occlusion treatment alternative. In this evidenced-based era of Dental Medicine, the journal's readership deserves to know that there is occlusal treatment help for their patients who live with chronic TMD symptoms.

These obvious deficits should have been detected by this journal's reviewers and editorial staff.

The authors multiple incorrect "facts" are detailed below by Manuscript section:

## IN THEIR ABSTRACT

"...but based on their specific features it can be suggested that the conventional method may be enough for most clinical purposes, **unless otherwise proven.**"

This statement in the Abstract cannot be made from this paper's Method, as nothing the authors found in their correlation proved that the conventional paper mark method was at least equal to the optical or T-Scan methods, only that the 3 methods did not correlate strongly to each other. Conversely, their invitation of "**unless otherwise proven,**" has already been addressed in multiple published studies, where the conventional method has been shown to be extremely inaccurate for evaluating force levels.<sup>1-6,20</sup> Previously published paper Mark Subjectivity studies,<sup>2,4</sup> and paper mark/force correlation studies have definitively proved that paper mark size and color intensity do not coincide with occlusal force levels or contact timing durations, and that dentists observing paper markings cannot accurately judge them, subjectively. More importantly, the fact that the authors accepted a subjective method without scientifically questioning its reliability, drastically lessens its academic credibility.

## IN THEIR INTRODUCTION

1. "*The paradigm about the ideal dental occlusion schemes in rehabilitation procedures has changed over time. Indeed, based on suggestions that the role of dental occlusion features is less important than believed in the past in the aetiology of temporomandibular disorders (TMD), bruxism or functional impairment, very basic occlusal schemes are enough to maintain the homeostasis of the Stomatognathic system.*"

This statement is completely incorrect. Here the authors are proclaiming their own paradigm, which excludes the well-known T-Scan based methods of occlusal diagnosis and computer-guided occlusal treatment simply by declaration. Never mind that Disclusion Time Reduction (DTR) applied exclusively with T-Scan has been repeatedly demonstrated in the literature to greatly improve many occlusally-related conditions and dysfunctional symptoms, even dramatically reducing the psychosocial symptom of depression.<sup>9</sup> For some reason the authors included an implant T-Scan article<sup>21</sup> along with other outdated T-Scan I and T-Scan II references,<sup>22-24</sup> but did not include any of the current T-Scan 10 literature, which establishes that very high precision occlusal schemes can optimize a patient's head and face muscle physiology and resolve many common TMD symptoms.<sup>6-19</sup> The original T-Scan and T-Scan II are no longer available. They were replaced first by T-Scan III and more recently by the upgraded T-Scan 10.

The authors go on to opine:

2. "Nonetheless, this does not mean that occlusion evaluations and adjustments should not be part of daily dental practice. Advantages and disadvantages of the conventional methods (e.g., articulating foil, paper, sprays and silk trips) are well known and documented. Actually, there is some technology available for digital occlusal evaluation that could contribute to overcome some potential shortcomings associated with the use of conventional methods. **However, few data are available on the usefulness of those digital methods.**

This statement is also false, and insinuates to an unknowing reader that there is limited documentation of accuracy or reliability data on the T-Scan system, despite the 30+ years of published accounts of T-Scan data being used in clinical treatment studies to therapeutically improve many occlusal abnormalities. The authors did not include this information even though PubMed lists 126 articles when "T-Scan" is searched and a multi-volume textbook, *Handbook of Research on Clinical Applications of Computerized Occlusal Analysis in Dental Medicine* (IGI Global) was published already in 2015 and has been updated with a new edition again this year.<sup>25</sup>

## IN THEIR METHOD

The Method contains the most egregious error of the entire study:

3. "An independent blind investigator (J.F.) analyzed visually the photographs based on the following rating: 0, absence of contact; **1. point contact with low intensity; 2. point contact with high intensity; 3. surface contact with low intensity; 4. surface contact with high intensity.** A reference photograph was used to standardize the classification.

The authors go on in the Discussion to assume (without qualification) that the independent investigator had the skill to reliably choose contact intensities by how the contacts on the splints appeared, giving him credit for accuracy when his/her accuracy was never tested or validated, but only assumed. Also, occlusal contact forces are not just binary (low and high), but include a continuum of levels (from very low force to very high force). All levels of relative force from no contact to maximum voluntary biting can be measured with T-Scan, but not by visual assessment. The weak correlation in this study actually proves that this investigator's visual estimation of forces was deficient when compared to measurements.

4. "The results demonstrated that the *clinicians have the ability to characterize occlusal marks properly and consistently (qualitative assessment).*

Nothing in the Method validates this statement as being true, as the independent investigator's classifications were not verified as being correct by measurement of the actual contact "force" intensities, nor was any explanation offered

as to what characteristics of the paper marks met the criteria of each of the four arbitrary categories. How a point contact was determined to be low intensity or high intensity, was never explained in any way. More importantly this visual process of detecting force levels has been proven in two previous studies to be highly inaccurate.<sup>2,4</sup> Nevertheless, the authors claimed that this subjective process was accurate and reliable in their study, ignoring the published research that definitively proves dentists observing paper marks can only choose even just high or low contact force intensities correctly at most 12.5% to 13.3% of the time.<sup>2,4</sup> When searching PubMed and the entire internet for "accuracy of interpreting contact forces from ink marks on teeth" only negative and cautionary results were found. Thus, it is a puzzlement where the authors got their contrary unreferenced ideas from.

## IN THEIR STATISTICS

The T-Scan force levels are not areas, and should not be considered as "corresponding values" to the absolute area values of the optical scanning method. The low Spearman correlation between the T-Scan measurements and the visual estimates of intensities ( $r = 0.265$ ) supports the lack of accuracy in the visual assessments (Note: The T-Scan values are measured, not a guess).

That the authors found any correlation between visual assessment and the T-Scan force measurements is at least partly due to chance (coincidence), but they did not report on that possibility.<sup>26</sup> Chance increases when a large number of values are tested, especially when only two choices are allowed and the correlation is low. (Note: When only two choices are allowed, such as high and low intensities, the chance of just guessing the correct choice is 50%.) This can be interpreted to mean that the actual correlation in this study between the T-Scan measured values and the visual assessment (recorded as  $r = 0.265$ ), is most likely only about half as much. That would agree well with previous studies indicating that the reliability of visual assessment of occlusal force intensity from paper marks is only about 13%. Often, two sets of random numbers, randomly associated, will exhibit a weak correlation. Of course, correlation is neutral, not indicating anything about cause or in the case of a low correlation, which factor is correct. However, when comparing a measured value to a visual guess, it should be obvious which one is correct and which one is wrong.

## IN THEIR DISCUSSION

Later in the Discussion the authors criticize the T-Scan sensor thickness as being a *potential* accuracy drawback:

5. "According to the results, a conventional occlusal analysis with articulation foil was able to localize, distribute and harmonize the shapes and area of the contact marks, even if not giving any information on the different loads.<sup>37</sup> On the other hand, the computerized assessment makes it theoretically possible to measure

***the load intensity in real time, but the thickness of the sensor could prevent an adequate analysis of the occlusal scheme. Furthermore, the actual influence of the sensor thickness on the recording procedure makes the internal validity of such device's findings potentially questionable."***

Previous studies have demonstrated the accuracy and repeatability of the T-Scan HD sensor.<sup>27-30</sup> That makes this statement another incorrect "opinion" or supposition, stated as if it were a "fact," again misleading the reader regarding the T-Scan sensors' proven capabilities to reliably measure relative forces and timing. The authors opined that the T-Scan sensor being "thick" affected its ability to accurately measure forces intraorally, but cited no scientific evidence. The fact that the T-Scan HD sensor Mylar matrix has been shown in several independent studies to maintain its integrity, and reproduce relative forces and time data consistently was not addressed.<sup>27-30</sup> One study that tested many occlusal indicator materials (T-Scan sensor, articulating paper, foil, silk ribbon, wax, and silicone imprints), reported the T-Scan sensor was the only material capable of reproducing the test environment 18 out of 19 times.<sup>31</sup> The authors included a few articles in their literature review, but either chose not to report the positive findings of the reliability studies or were not diligent enough in their literature search. Instead they suggested to the unfamiliar reader that sensor thickness could be a T-Scan accuracy drawback.

Conceptually, it seems logical that a thinner sensor would alter how the teeth come together as little as possible. However, digital sensors measure force-spread across the occlusal surface out from the actual contact. It is not occlusal contact that is being registered by a T-Scan HD sensor. Importantly if digital sensors are too thin, they can perforate, which electronically corrupts the force and timing data being gathered. As such, digital sensor durability is essential, so that a sensor's structure stays intact while being repeatedly crushed inter-occlusally during the recording process. The T-Scan sensor "thickness" then becomes a positive physical attribute, in that appropriate sensor dimensions can both withstand the stresses of occlusion, and repeatedly, reliably report consistent force and time values, without sustaining frequent perforations.<sup>32</sup>

Later the authors misstate facts once more, this time to bolster this paper's position as being a "first," when in actuality this study is nowhere near the first attempt in vivo:

6. "Thus, from a clinical viewpoint, this study should be viewed as a first attempt to relate in vivo, in a reproducible way, findings from a clinical and a computerized occlusal analysis procedure."

These authors give themselves undeserved credit as being the first to correlate paper markings to occlusal forces. And although they found what was already known (that paper mark area does not correlate strongly to occlusal force levels), Kerstein and Radke in 2013 did the 1<sup>st</sup> successful scientifically correct study intraorally,<sup>2</sup> which showed the accuracy of a doctor's paper mark choices as being very poor at 12.5%. And then Sutter published a second success-

ful study in 2017, that replicated the Kerstein and Radke study, where he found a 13.3% accuracy rate for visual interpretation of occlusal force levels.<sup>4</sup>

It is indeterminable whether these authors are pushing a biased agenda to mislead the profession regarding the T-Scan or whether the JOR was just extremely lax in their review process to qualify this article. It is inconceivable that the existing, inaccurate, and outdated paper mark subjective method is still considered adequate for patients, in light of the availability of the measured accurate and proven computer methods. This almost appears as an attempt to obfuscate the paper mark inaccuracy truths proven in the previous research done on paper marks with measured force levels over the past 13 years. However, the actual data they recorded, with proper interpretation, supports that the subjective paper mark interpretation method has a high degree of inherent inaccuracy and is far worse for patients than using a measured computer-guided approach.

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STATEMENT OF CONFLICTS

Dr. Kerstein is a consultant to Tekscan, Inc. but receives no monetary gain from sales. Mr. Radke is the Chairman of the Board of Directors for BioResearch Associates, Inc. receiving no money from sales.

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