Critical flaws in the T-Scan digital occlusion analysis system

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Abstract

The T-Scan digital occlusion analysis system has previously been criticized for its use of artefactual measurements. Far more than the traditional clinical occlusion detecting armamentaria (paper, film and silk), its crown-sensor-crown configured force measurements misrepresent the actual crown-crown contact forces.

Yet another defect, thus far unaddressed, is the misapplication of basic Newtonian static equilibrium principles, presumably the basis of their (proprietary) numerical algorithm. The approach requires the complete characterization (magnitudes, directions and points of application (or the lines-of-action)) of the occlusal contact force vectors. Instead, because of inherent sensor limitations, their elaborate mechanics calculations rely on artefactual force magnitudes, assumed directions, and estimated contact locations. Thus, the seemingly impressive T-Scan analyses are, essentially, groundless.

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The characterization of occlusal contact forces has been an enduring challenge for the dental profession, with countless investigations and persistent controversies. The universal clinical armamentaria for assessing occlusal contacts are ink-based marking indicators (paper, film, silk, etc.) and, to a limited extent, the state-of-the-art electronic/computer-based T-Scan system (Tekscan, South Boston, MA, USA).

The preponderance of occlusal contact force studies, conflicting and non-conclusive, have dealt with the visual interpretations of ink markings as indicators of contact force magnitudes. Only a few studies have focused on the more basic issue about the effects of these products on the contact forces themselves, the entities that they purport to measure. But recent studies have shown that the presence of these products, above all, T-Scan, significantly alter the occlusal contact force magnitudes and/or directions. Thus, the ink marks and the raw T-Scan data reflect artefactual occlusions that are unique to each product depending on its thickness, stiffness and surface (friction).(Helms, Katona et al. 2012, Mitchem, Katona et al. 2017, Mitchem, Katona et al. 2018, Beninati and Katona 2019) Notably, these distortions of the occlusion are readily acknowledged by the most zealous advocates of T-Scan.(Mitchem, Katona et al. 2018, Sutter and Radke 2018)

One implication for the traditional products is that the long-standing ink-spot interpretation controversies are somewhat pointless given that markings are not representative of the actual crown-crown contacts, and that the artefactual occlusions are specific to each product. The repercussions are direr for the T-Scan system because it uses measurements of the "self-inflicted" artefactual occlusions as input to the computer processing that produces the highly-touted elaborate clinical displays and treatment guides.

But, the main purpose of this short essay is to highlight yet another, thus far unaddressed, fatal flaw in the T-Scan system – the algorithm behind the computer calculations. Unfortunately, there are no readily available details about that process because, apparently, the methods are proprietary.(Ahuja 2009) With no information to the contrary, and because practical alternatives do not exist, it must be presumed that the T-Scan computations are based on basic Newtonian force and moment static equilibrium principles.

Forces and moments are vector quantities because, in addition to the magnitude of a scalar quantity, they also possess direction. Furthermore, to define a *force* vector, an occlusal contact force for example, its point-of-application, or its line-of-action (LOA), must be specified. To solve a static equilibrium problem, some load (force and/or moment) magnitudes *and/or* directions *and/or* LOAs must be known (*i.e.*, measured, specified or assumed), and used in the governing equilibrium equations to calculate all, or some, of the remaining unknown load magnitudes/directions/LOAs.

T-Scan claims to measure the individual occlusal contact force magnitudes and asserts the ability to pinpoint the contact locations (https://www.tekscan.com/products-solutions/digital-occlusal-analysis). Magnitude and location comprise 2 of the 3 required force vector parameters noted above. But, the T-Scan contacts are localized relative to its flat undeformed sensor, not relative to the "cuspy" terrain of the occlusal plane. Furthermore, the contacts are between crown and sensor, not crown and crown. Thus, T-Scan-measured contact force magnitudes and locations are entirely artefactual.

Occlusal contact force direction (the 3rd essential attribute of a force vector) is rarely (if ever) mentioned in the T-scan literature. Hence, purely by conjecture based on promotional images, the calculations may be using the assumption that the individual occlusal contact forces are perpendicular to the occlusal plane. That would be the simplest and most intuitive configuration, but unfortunately, 100% wrong if there are any cusp incline contacts. The bottom line is that the sensor cannot provide force orientation, so for computational purposes, contact force directions must be assumed.

Thus, the T-Scan system relies on calculations that use artefactual occlusal contact force magnitudes, approximated artefactual contact point locations, and assumed occlusal contact force directions. As magnitude, location and direction comprise the 3 essential defining parameters of a force vector, based on the available information and basic engineering mechanics, it must be concluded that meaningful T-Scan analyses are impossible.

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