

## Chapter 35

# Precision and Reliability of the T-Scan III System: Analyzing Occlusion and the Resultant Timing and Distribution of Forces in the Dental Arch

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### **ABSTRACT**

*Precise analysis of occlusal contacts and occlusal force is a problem in functional diagnostics that has not yet been satisfactorily resolved, despite the fact that the deleterious consequences of an unbalanced occlusion are widespread and can be severe. In clinical practice, the present-day analysis of the occlusion is reduced to depicting force with color-marking foils that leave ink marks upon the teeth. However, these foils only indicate the localization of contacts, but do not describe reliably the occlusal force relationships. Precise analysis that incorporates time resolution and plots the distribution of forces within the occlusion is not possible when employing the traditional occlusal indicator methods. A detailed occlusal force and timing analysis can only be provided by performing a computer-assisted analysis, using the T-Scan III system (Tekscan, Inc. S. Boston, MA, USA), which records changing relative occlusal force levels and real-time occlusal contact sequence data with High Definition (HD) recording sensors. This chapter demonstrates the accuracy and reliability of this computer-based occlusal measurement method that reliably describes the time-dependent distribution of occlusal force evolution.*

### **INTRODUCTION**

A smooth and functional occlusion is basic and central to all sub-disciplines of dentistry, including orthodontics (Andrews, 1972). In conservative restorative dentistry, the presence of a harmonious and smooth occlusion is considered essential to the physiological function of the Stomatognathic system, and is deemed essential to protect against excessive loading and fracture of inserted restorations and

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dental implants. In orthodontics, harmonious occlusal relationships are required to ensure the stability of achieved treatment outcomes. It is a vital element of therapeutic dentistry to accurately and realistically record and analyze the occlusal relationships of examined patients, by the use of occlusal indicators (foils, papers, silk ribbon) or instrumental occlusal diagnostics. This chapter will focus mainly on the reproducibility and reliability of methods. What follows is an analytical presentation of the temporal sequence of occlusal force buildup that can be observed with the T-Scan III occlusal analysis system (Tekscan, Inc. S. Boston, MA USA). This topic will be discussed against the background of the available literature regarding the conventional, non-digital, occlusal indicator diagnostic methods.

## **BACKGROUND**

### **Occlusal Indicator Limitations**

The problem of how to precisely analyze occlusal contacts for functional diagnosis has not been acceptably solved to this day (Balters, 1955; Gazit, Fitzig & Lieberman, 1986; Komari, 1978; Millstein, 1983; Reiber, Fuhr, Hartmann & Leicher, 1989). No aids other than color-marking foils, articulating papers, and silks were formerly available for clinicians to check occlusal contacts in daily clinical practice. While indicators of this type disclose the location of contacts, they provide no information about the relative occlusal forces, nor the timing of the contact sequences. Given a mere 21% reliability of association between occlusal markings and force levels, any conclusions drawn on this basis have been described by Kerstein as “tantamount to clinical guessing” (Carey, Craig, Kerstein, & Radke, 2007; Kerstein, 2008; Kerstein & Radke, 2013). Due to this inadequate representation of force vectors present at contact points relative to the markings on tooth surfaces, the usefulness of these indicators should be solely confined to their role as contact locators.

In addition, the markings offered by these foils and strips are not adequately reproducible, but will somewhat increase in reliability at higher force levels (Gazit, Fitzig & Lieberman, 1986; Millstein & Maya, 2001; Reiber, Fuhr, Hartmann & Leicher, 1989). Moisture and repeated use, in particular, will considerably impair the sensitivity of conventional occlusal indicators (Saracoglu & Ozpinar, 2002). Reiber, et. al., determined, that foil markings offer more accurate marks than those made from papers and silks, but paper indicators will yield better results than foils when marking glossy surfaces, such as with abraded wear facets and highly polished restorations, because the dye released from foils marks less predictably in those clinical situations (Reiber, Fuhr, Hartmann & Leicher, 1989). Since tracings created by foils are also unpredictable in the presence of low or impulse-free loading, higher forces need to be exerted (such as with chopping movements), introducing an additional source of error to the occlusal analysis (Reiber, Fuhr, Hartmann, & Leicher, 1989). However, it has been suggested that these conventional foil and articulating paper techniques will yield reproducible results at an acceptable level of variance, in the hands of adequately experienced and prudent clinicians (Tschernitschek, Handel & Gunay, 1990).

### **Indicator Thickness**

A general concern relates to the thickness of the differing indicators. Foils are the thinnest materials among the spectrum of indicators available in the market. While the specified values of strip and foil indicators

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