

Force Finishing and Centering to Balance a Removable Complete Denture Prosthesis Using the T-Scan III Computerized Occlusal Analysis System

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Abstract Obtaining bilateral balance of removable complete denture prostheses is the occlusal goal of the restorative dentist or prosthodontist. Despite our best clinical efforts, and the using of advanced mechanical devices like semi-adjustable articulators and face bow transfer mounting of dental casts, it is a struggle to provide accurate occlusal force balance. Some of the advocated reasons for the clinical difficulty of obtaining reliable occlusal balance are that stone casts lack soft tissue resiliency, and articulators only approximate human occlusal functional movements. However, modern technology offers clinicians a digital answer to this clinical force balance problem. It is known as computerized occlusal analysis. The T-Scan III system can be employed with complete removable denture prostheses to perform computer-guided occlusal force-finishing corrective adjustments that measurably improve the installed prosthetic occlusal balance.

Keywords Measurable occlusal balance · T-Scan III computerized occlusal analysis system · Force-finishing · Force centering

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Introduction

Occlusal forces that can destabilize a complete denture prosthesis during function can result from a poor occlusal force summation location [1, 2]. This unseen collection of unbalanced forces can assist in movement and dislodgment of both upper and lower opposing complete dentures, while the prostheses are subjected to occlusal function. Developing a complete denture occlusion that aligns the occlusal forces along the posterior midline of the hard palate and within the center of the distribution of occlusal contacts will insure the denture is seated vertically during occlusal loading upon the most supportive edentulous tissue-bearing area. This force-finishing computer-guided technique [3, 4] can be employed to direct the seating of a removable prostheses, so the maxillary and/or mandibular complete denture will be compressed vertically to its' seat, as opposed to being subjected to non-vertical, off-center occlusal forces.

Force centering [5] is an occlusal adjustment goal which can be applied to any full arch dental prosthesis; maxillary and mandibular complete dentures, complete arch fixed implant-supported prostheses, complete arch porcelain fused to metal, and metal-free prostheses involving all-ceramic crowns and fixed bridges. This procedure can also be employed with combinations of both fixed and removable prostheses where complete dentures oppose removable dentures retained with attachment crowns (Fig. 1).

The T-Scan III (Version 7, Tekscan, Inc. S. Boston, MA, USA) [6] center of force (COF) trajectory and summation icon [7], aids the clinician in improving the orientation of the occlusal force summation during a complete denture insertion force-finishing occlusal adjustment procedure. The occlusal forces (of a removable prosthesis) can be observed within the T-Scan III desktop (Fig. 2), which is

organized into four panes; the 3-dimensional column view (upper left pane; force levels illustrated by color-coding and column height), the 2-dimensional contour view (upper right pane; force levels illustrated by color-coding and occlusal surface location) that houses the COF trajectory, its' red and white diamond-shaped icon, and the white/gray COF ellipse, (the ellipse is a "target" that assesses overall prosthesis force balance), the force versus time graph (lower right pane) and the zoom graph (lower left pane). Each of these panes allows the clinician to observe the recorded occlusal force and time-sequence data that guides the occlusal adjustments accomplished during the insertion of a complete denture.

The clinician can use this graphically displayed occlusal data to correct a poorly summated (an off-center occlusal

force balance) and deliver a set of complete dentures that is Force-finished to measurable occlusal balance. By performing computer-guided occlusal adjustments, the clinician can relocate an off-center COF and position it on the arch 1/2 midlines within the white/grey elliptical target. When the COF icon is positioned here, the prosthesis occlusal force summation is concentrated within the center of the removable prostheses, which will seat the complete dentures vertically.

The force versus time graph (Fig. 3) describes the entire occlusal event from start to finish. There are 2 "intercuspatations" that the patient made in Fig. 3. The black curving line is the total force line, which raises, crests, and drops as the patient occludes, holds their teeth together, and then opens their occluded teeth. The red (right arch-half) and green (left arch-half) lines illustrate the changing occlusal force percentages of each arch half, as they evolve within the recorded movie. Once the patient has reached complete occlusal intercuspatation, the red and green lines will become parallel to each other (in bite 1 at 1.795 s; at B1). The degree of red-green horizontal line separation indicates the degree of prosthesis right to left force percentage imbalance.

Clinical Force-Finishing and Force-Centering Procedures

When a complete denture is inserted into the patient's mouth, it is assessed for: proper stability and retention, any



Fig. 1 Maxillary complete denture versus mandibular attachment removable partial denture. The prostheses appears to be balanced because all the teeth have visual contact

Fig. 2 T-Scan III desktop with 4 panes of data illustrating a significant left side force excess (62.5 % left-37.5 % right) of this complete denture versus a mandibular partial denture. Note that the COF icon is anterior and left of the white/gray COF ellipse illustrating a destabilizing left anterior occlusal force summation

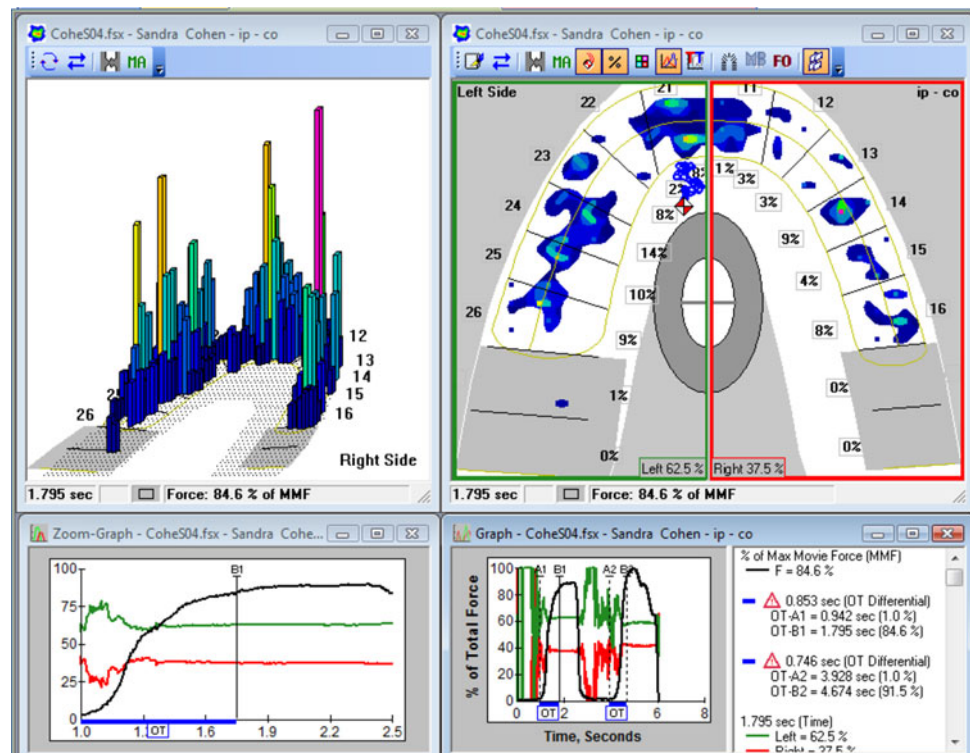
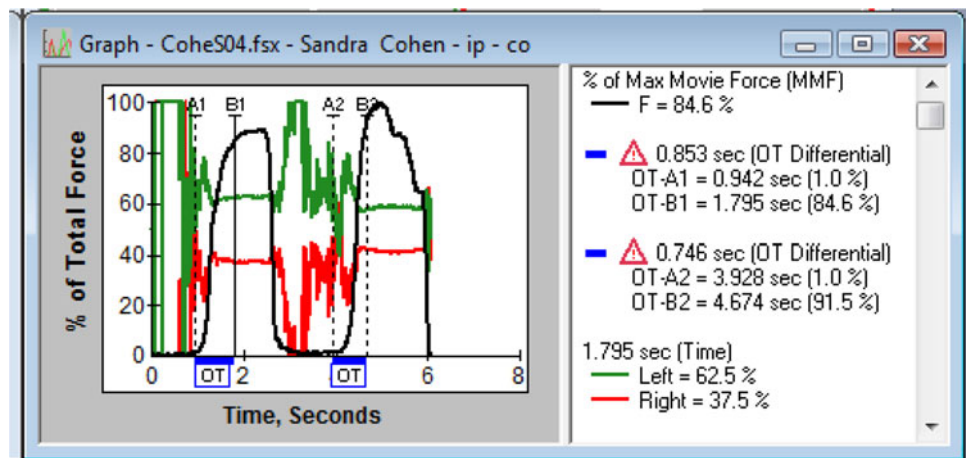


Fig. 3 The force versus time graph from Fig. 2



over-extension, any lack of frenal relief, any areas of soft-tissue pressure, the overall aesthetic appearance of the tooth setup after processing, and the overall occlusal force balance [8]. This is where the T-Scan III system can be used to evaluate the pre-adjusted force imbalance and the contact timing characteristics of the complete dentures at insertion.

A properly performed full closure scan will provide the clinician with the inequality of the prosthesis occlusal balance.

Full Closure Movie Recording Technique

Insert the T-Scan sensor intraorally by resting the T-Scan sensor support within the facial central incisor embrasure of the maxillary denture's central incisor teeth. Then activate the recording by depressing the Record Button on the top of the T-Scan III recording handle (Fig. 4a, b).

The patient is then asked to firmly intercusate into the sensor using their complete denture occlusion, and to firmly hold their teeth together for 1–3 s once maximum intercuspation is reached. To capture 2 intercuspations (as in Fig. 3) the patient opens after the first intercuspation, and then re-intercusates into the recording sensor firmly, once again. This type of recording illustrates the force details of the occlusal contact time-sequence from 1st tooth contact thru to complete intercuspation, while simultaneously describing the history of the right to left arch half force imbalance of the contact closure sequence.

Although the complete denture and partial denture in Fig. 1 appear to be balanced because the teeth of both prostheses are in visual contact, Figs. 2 and 5 illustrate that the posterior left, anterior left central incisor, and one posterior right premolar denture teeth, are comprising most of the occlusion (teeth #s 24, 25, 26, 21, and 14). To correct this 62.5 % left–37.5 % right imbalance, force-centering of this prosthesis combination is accomplished by:

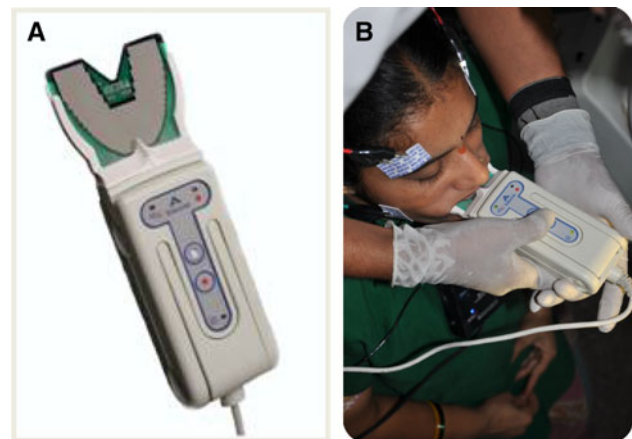


Fig. 4 a T-Scan III recording handle with sensor and sensor support in place. The record button is the red dot in the middle of the handle. b Proper patient sensor positioning for a full closure scan

1. Making sequential T-Scan III move recordings of the patient self-closing into complete denture intercuspation. These recordings capture the off-center force profile of the occlusal balance
2. Observing the COF position, and the force versus time graph for the degree of occlusal force imbalance between right and left sides of the prosthesis. The off-center COF position in Fig. 5 indicates that the denture will be destabilized to the left anterior by the occlusal force summation of the complete maxillary denture and the mandibular partial denture.
3. Mark the specific contacts with articulating paper (Accufilm II Black, Parkell Inc. Farmingdale, NY, USA) based upon the overloaded contact locations detailed within the T-Scan III 2-dimensional pane, then adjust those specific contacts only, and then record another post-adjustment full closure scan. This next recording is accomplished to measure the force changes resultant from the 1st set of corrective adjustments to the problematic denture teeth.

- Repeat this process until the COF assumes a midline balanced position and the right to left force balance approaches 50 % bilaterally.

An example of employing this technique can be seen in Figs. 5, 6 and 7, where the existing occlusal contacts seen in Figs. 2 and 5 if left untreated will drive the denture to the anterior left. The denture teeth that are comprising most of the occlusal imbalance are #s 24, 25, 26, 21, and 14. These five overloaded contacts require significant force reduction, in order to improve the force distribution and improve the right to left arch-half force balance. These are the only teeth be marked with articulating paper, and the only teeth to be adjusted, regardless of the other paper marks present on other denture teeth.

Figure 6 illustrates the new balance profile of the second full closure scan, that resulted from the corrections based upon the first full closure scan. Note that there is improved right to left balance, now 54.7 % right–45.3 % left, which is only a slight occlusal force imbalance. Now the COF trajectory (the blue line attached to the white and red

diamond) starts within the central incisor region and then travels down the midline, indicating there is improved bilateral force distribution from 1st to last contact in the entire closure sequence. At complete intercuspation, there is now lessened left posterior overload, increased right posterior overload (#s 15, 16), and persistent but lessened left anterior overload on tooth #21. The central incisal region maintains a broad area of low “blue” occlusal force. This indicates there is excessive surface engagement of the lower anterior teeth against the upper lingual surface of the maxillary anterior denture teeth.

After the 3rd set of occlusal adjustments performed to teeth #s 15 and 16, and 21 (both blue and light green force zones), that were based upon Fig. 6 occlusal balance data, the denture is now measurably balanced, with a 50.1 % left–49.9 % right force distribution (Fig. 7). This near-perfect force balance was created by targeting only those contacts that the T-Scan III revealed as requiring occlusal treatment in each successive movie. Note that in Fig. 7, the COF trajectory starts more posterior than in Fig. 6,

Fig. 5 T-Scan III force data showing overall 62.5 % left–37.5 % right force imbalance. The COF is off-center (located to the left anterior of the white/grey ellipse) resultant from the left sided occlusal force summation present when the opposing complete dentures are fully occluded

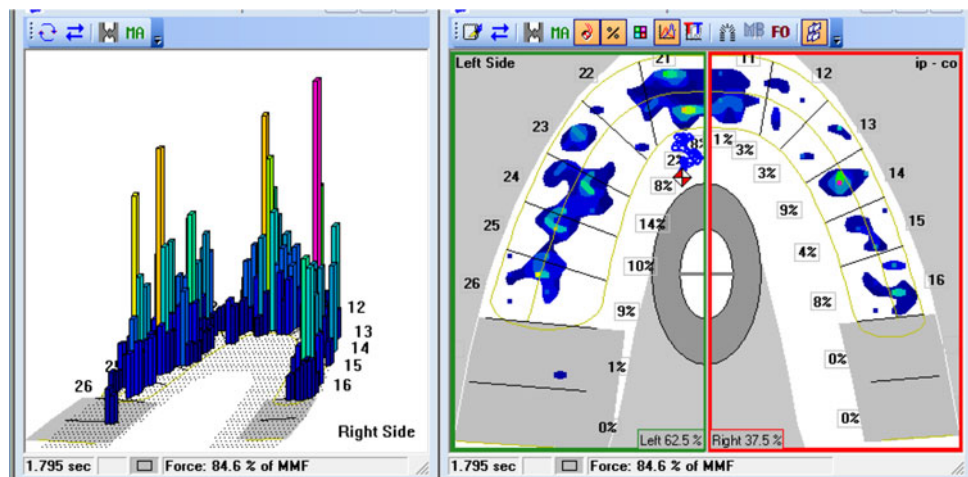


Fig. 6 Force balance after 1st set of corrective T-Scan III guided occlusal adjustments to teeth #s 24, 25, 26, 21, and 14

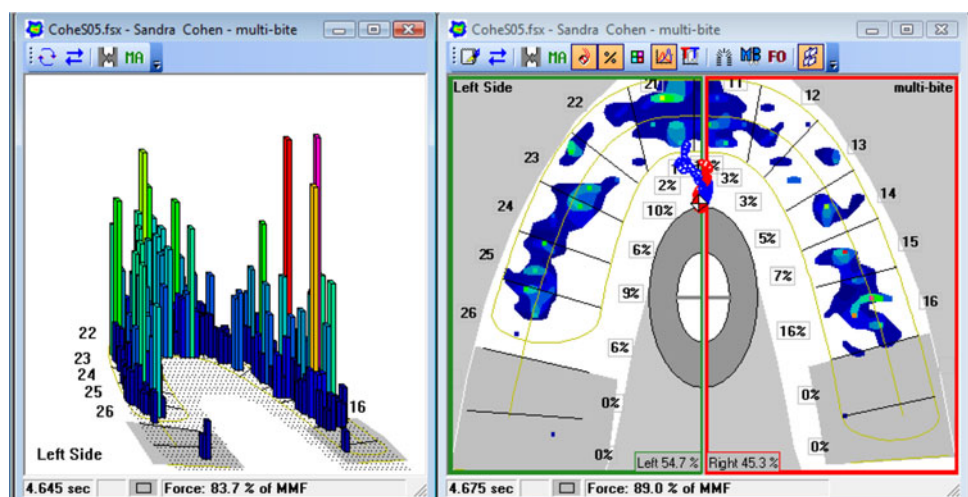
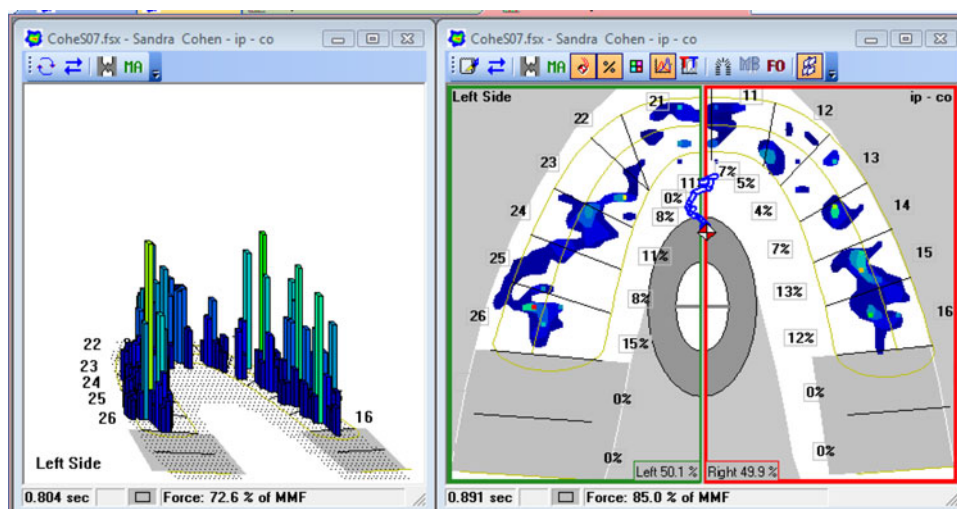


Fig. 7 Force balance after 2nd set of corrective T-Scan III guided occlusal adjustments to teeth #s 15, 16 and 21. This occlusal adjustment end-result aligns the occlusal forces along the *midline* of the hard palate with nearly 50 % right–50 % left occlusal force balance, with reduced overall occlusal force intensity compared to Fig. 2 pre-treatment



indicating the excessive surface engagement of the lower anterior teeth against the upper lingual maxillary anterior denture teeth has been relieved. The COF icon is now centered within all the occlusal contacts. Also note that in the 3-dimensional column pane, there are only blue and light green (moderate) occlusal force columns present at maximum intercuspation. This indicates that the elevated occlusal forces present pre-treatment (in Fig. 2) have been significantly lessened. The entire occlusal force balance has been force- finished to measurably improvement by employing the T-Scan III system to guide the corrective occlusal adjustments.

Summary

Force centering of a complete denture prosthesis results in the occlusal forces being directed to eliminate unbalanced side-to-side torquing of the prostheses. This desirable prosthesis insertion end-result is accomplished by utilizing the data acquisition and occlusal force display features of the T-Scan III computerized occlusal analysis system. By employing a full closure force movie recording, the force versus time graph, and the COF occlusal force summation analysis, the clinician can readily observe where the occlusal forces are distributed and what specific occlusal adjustment corrections can be performed to achieve a centered and measurably balanced force distribution. This

complete denture insertion occlusal adjustment end-result, aligns the occlusal forces along the midline of the hard palate with a nearly 50 % right–50 % left occlusal force balance. This balanced force distribution improves the tissue seat of the denture by insuring that, while the denture is loaded during mastication, it is seated by the occlusal force summation onto the broadest and most supportive tissue available.

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