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Effect of mandibular complete dentures relining on occlusal force distribution using T-scan system

Eman M. Ibraheem[1] and Hisham S. ElGabry[2*]

Abstract

Background: This study aimed to evaluate the effect of mandibular complete dentures relining using soft relining material on the distribution of various occlusal forces using T-Scan system. Fifty completely edentulous patients having their conventional complete dentures earlier fabricated and utilized were selected for this study. Patients were controlled diabetics, characterized by having their residual alveolar ridges moderately developed and lined with firm mucoperiosteum. Mandibular complete dentures were relined with soft denture liner and T-Scan device was used for occlusal force distribution measurement prior to denture relining and three months thereafter the relinning procedure.

Results: Comparison between occlusal forces percentages before and after denture relining revealed that occlusal forces percentages was significantly lower after denture relining in anterior area, significantly higher after denture relining in right posterior area, where it was insignificantly higher after relining in left posterior area.

Conclusions: Our findings revealed that the use of soft denture liner for mandibular complete denture relining significantly improved the occlusal load distribution.

Clinical trial registration Trial registration NCT, NCT04701970. Registered 23/11/2020—Retrospectively registered, https://clinicaltrials.gov/ct2/show/NCT04701970

Keywords: Complete dentures relining, Occlusal force distribution, T-scan system

Background:

Alveolar bone reduction is almost always a consequent of teeth loss associated with advanced age. As a matter of fact, the reduced ridge height and width greatly affects complete dentures retention and stability specially the mandibular complete denture (Misch 2008; Ibraheem et al. 2019; Doundoulakis et al. 2003). Furthermore, reduced lower denture retention and stability has a great impact on the patients' masticatory efficiency, self-confidence, prosthesis usage satisfaction, and, hence, their

quality of life (Jain and Rathee 2019; Ibraheem and Hammad 2019).

The mandibular complete denture retention could be more superior by applying different methods as clinical guidelines, flexible materials, pre-prosthetic surgeries that improve denture foundation or by using dental implants (Ibraheem et al. 2019; Pradeep et al. 2015). Nevertheless, soft denture liners and denture adhesives are other modalities that could improve complete denture retention (Ibraheem and Hammad 2019; Pradeep et al. 2015; Elmorsy et al. 2015). Denture lining materials whether temporary or permanent are highly effective materials that greatly improve denture adaptation to underlying tissues. Hard liners are mainly resin-based polymers which are manufactured from poly-methyl

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methacrylate (PMMA) (Atay et al. 2012). Whereas, Soft resilient liners whether long-term or short-term types are plasticized acrylic resins or silicone elastomeric type of materials which can equally distribute functional load on denture foundation areas (Atay et al. 2012; Kreve and Dos Reis 2019).

It is to be mentioned that complete denture retention is, in part, influenced by denture occlusion. Most denture wearers consciously perform random, occlusal contact movements at all times. These contacts may result from functional activity (swallowing) or parafunction (bruxism or clenching). A well balanced denture occlusion is intended to minimize the adverse effects of functional and parafunctional movements by widely distributing these forces to the denture bearing areas. Therefore, a properly balanced denture occlusion may serve to properly distribute occlusal forces that may act to disturb denture stability (Kreve and Dos Reis 2019; Koos et al. 2010).

Conventional clinical assessment techniques for occlusal contacts equilibration include the use of either articulating paper/indicator wax or patient feedback (Koos et al. 2010; Qadeer et al. 2012). Whereas, even though articulating paper is the most commonly used method, it is an undependable indicator of actual occlusal load as its markings depend mainly on the occlusion quality, anatomy, and type of saliva, which can cause false positive marks (Kerstein 2008).

Lately, the occlusal equilibration using computerized assessment methods as the T-Scan system that appeared in 1987 has been widely used and offers reliable results. The latest version (T-Scan III) provides a unique method of occlusal load evaluation dynamically from the time of initial tooth contact to maximum teeth intercuspation. This system records different values for occlusal force besides, allowing occlusal balance evaluation through recording values for occlusion and dis-occlusion numerically (Maness et al. 1987; Martins et al. 2014; Kerstein et al. 2013).

Occlusion time is known as "time from the first occlusal contact to maximum teeth intercuspation", whereas the disocclusion time is known as "time from maximum teeth intercuspation to complete disocclusion" (Gümüs et al. 2013). The main target is to reach occlusion time in less than 0.2 s and disocclusion time in less than 0.4 s. Less Occlusal time means less prematurity and is an indication of simultaneous occlusal contact. Whereas, the less the disocclusion time the less the stresses upon the temporomandibular joints (Kerstein and Radke 20062).

Furthermore, even distribution of occlusal forces over denture foundation areas, reduces the occlusal stress concentration and lowers possible residual ridge resorption rate. T-Scan is definitely helpful in providing data about measurable occlusal force distribution which is nearly 50% occlusal force balance on both jaw sides improving the dentures tissue adaptation during patient mastication. Thus, T-Scan usage would be of great help to achieve simultaneous occlusal contact and correct occlusal prematurities more accurately (Kerstein and Grundset 2001; Tallgren et al. 1992).

The contact areas registered by T-Scan are represented as multiple columns of different heights and colors indicating the occlusal forces intensity. The amount of occlusal force is color coded as the red color represents the maximum force and the blue color indicates the minimum force. T-Scan measures the relative occlusal force values from initial tooth contact to maximum teeth intercuspation. Furthermore, it marks the abnormal occlusal forces in every tooth in the denture which may lead to trauma or pain and thereby, helps to balance the forces on both sides of the arch (Maruo et al. 2010).

Diabetes mellitus is a chronic metabolic endocrine disorder and is one of the most widely spread diseases which is almost found in most elderly dental patients. It has been classified into type 1, type 2, Hybrid forms, unclassified diabetes where, Type 2 accounts for more than 90% of diabetic patients (Metwally 20199; Rahman 2013).

Ketone breath, gingival and periodontal disease, alveolar ridge resorption, candidiasis, and xerostomia are the most common oral manifestations of diabetes (Mauri-Obradors et al. 2019). Also, reduced oral mucosa resiliency is evident, which is of utmost necessity for good dentures adaptation, as complete dentures retention for diabetic patients was likely found to be less than non-diabetic patients (Mauri-Obradors et al. 2017; Kansal and Goyal 2013).

This study aimed to accurately assess the impact of soft denture liners using T-Scan III computerized occlusal analysis system on occlusal equilibration in diabetic complete denture patients.

Methods

The crossover clinical study was made using already constructed and utilized complete dentures before attempting relinning procedure using soft denture liners and then after being relined with soft denture liners. The study sample included 50 completely edentulous male patients, 49–63 years old (with an average of 56 years). Patients were chosen from the out-patient dental clinics of Medical Excellence Centre, NRC. Patients were controlled type 2 diabetes (i.e. fasting serum glucose level was higher than 126 mg/dl) as well as the glycosylated hemoglobin level (HbA1c) does not exceed 7.5% during the study phase. All patients were non-smokers with Angle class I classification and no history of temporomandibular/neuromuscular disorders, where bruxers and heavy clenchers were totally excluded from the study. All

patients were characterized by having moderately developed alveolar ridges lined with firm mucoperiosteum. On the other hand, patients with medical problems or chronic diseases except diabetes or any intraoral soft or hard tissue pathology were totally excluded from the study. Intra/extra-oral examinations, panoramic radiograph and diagnostic casts were made for all selected patients. Furthermore, all patients were instructed to keep the denture fitting surfaces cleaned and get their dentures removed at bed time, keep them in a water basin overnight and massage their oral tissues gently.

Prosthodontic management

All selected patients have been daily using their conventional heat cured acrylic resin complete dentures for at least two years with definite history of mandibular dentures problems primarily related to retention and stability (Soman and Bhatnagar 2014).

After that, the mandibular complete dentures received the necessary prosthetic adjustments to achieve optimal retention and stability together with perfection of occlusal contacts, where the first occlusal force measurements were made before the dentures being relined. T-Scan device was used for occlusal force distribution measurement prior to denture relining and three months thereafter the relinning procedure.

Relining technique (direct—abrasion method)

- Relining of mandibular dentures was made by making a relief of 1–1.5 mm of the denture fitting surfaces and borders to achieve borders of right-angle.
- Long-term soft lining (LTSL) material (MUCO-PERN-SOFT Kettenbach GmbH and Co. Kg, Germany), manipulation was performed following manufacturer instruction.
- Afterwards; Mucopren adhesive was applied in two separate layers on the mandibular denture vestibular surface and each layer was allowed 40 s to dry.
- Mandibular denture-fitting surface was filled with an even thickness of LTSL using the manufacturer syringe.
- Then, mandibular denture was inserted in patients' mouth and the material was molded accordingly; while asking the patient to close gently in centric occlusion with the opposing denture.
- After complete setting of LTSL material, trimming of excess material was performed and finally dentures were inspected, finished and polished.
- Strict post-insertion denture care protocol was reassured with all patients.
- All required intraoral denture adjustments were made on the day of denture insertion and continued throughout the first week make sure that all patients were free from any possible dentures discomfort.

Patients were then asked to routinely use their relined dentures daily for at least three months then; dentures retention and stability were assessed before further recording of occlusal force distribution.

Evaluation of occlusal force equilibration

The occlusal force distribution evaluation was carried out using the T-Scan device (Tekscan Inc., South Boston, MA, USA) (Figs. 1, 2). The first record was made before denture relining and the second record was made after three months of denture relining as follows:

A sensor of the appropriate size was selected according to dentures form and arch size. Then, patients were instructed to sit upright and parallel placement of the sensor to the maxillary occlusal plane was made with the midline was marked between the central incisors. To adjust the sensor sensitivity; patients were instructed to trial bite 2–4 times before recording then, they was instructed to bite in maximal intercuspation with the sensor positioned between the upper and lower dentures and to keep biting for 1–3 s according to the manufacturer instructions. The procedure was repeated three times and the recorded movie was saved on the computer

Fig. 1 T-Scan device and the sensors

Fig. 2 T-Scan device in patient's mouth

for analysis and all measurements were made by one examiner. The percentage (%) of occlusal force distribution for both anterior and posterior denture areas in each quadrant were recorded. Finally, the mean values were calculated from the three recordings & the data was saved for statistical analysis (Figs. 3, 4).

Results

Data were presented as mean and standard deviation. Data were presented in one table and one graph. Statistical analysis was performed with SPSS 16 ® (Statistical Package for Scientific Studies), Graph pad prism and windows excel.

Paired t-test was performed between occlusal forces percentages before and after denture relining, while comparison between different areas was performed by One Way Repeated ANOVA, followed by Tukey's post hok test for multiple comparisons as presented in Table 1 and Fig. 5.

Comparison between occlusal forces percentages before and after denture relining performed by paired *t* test revealed that occlusal forces percentages was significantly lower after denture relining in anterior area, and significantly higher after denture relining in right posterior area, where it was insignificantly higher after relining in left posterior area as presented in Table 1 and Fig. 5.

One Way Repetitive ANOVA was performed in each group to compare between three areas and revealed significant difference between them ($P < 0.05$), followed by Tukey's post hoc test for multiple comparisons which revealed significant difference in means with different superscript letters (anterior area and right posterior– anterior area and left posterior before and after denture relining), while revealed insignificant difference in means with the same superscript letters (right and left posterior area before and after correction) as presented in Table 1.

Discussion

Patient satisfaction is directly affected by the denture stability; which is mainly influenced by presence of balanced occlusal contacts. Most commonly, at the time of insertion and post-insertion recall visits, complete denture
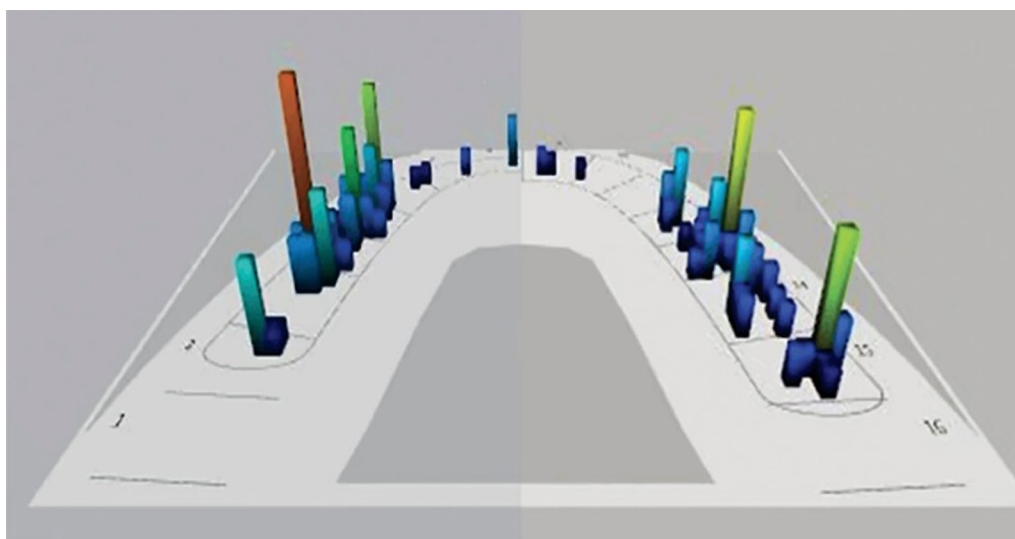

Fig. 3 T-Scan record after denture relining, the right side shows absence of high intensity force columns and more favorable force distribution pattern, while the left side shows premature contacts at particular areas, indicated by red columns (representing higher intensity forces)
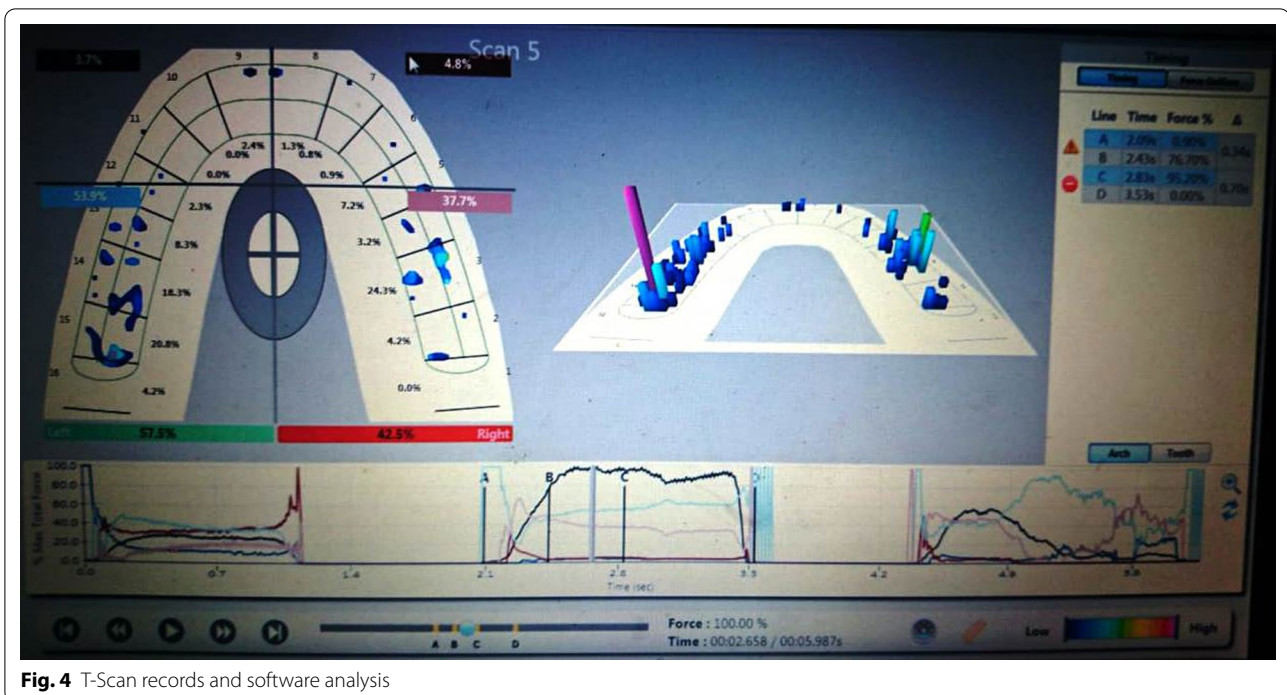
Fig. 4 T-Scan records and software analysis

Table 1 Percentages of Occlusal forces before and after denture relining in anterior, right posterior and left posterior areas

	N	Anterior area		Posterior right		Posterior left		P value
		M	SD	M	SD	M	SD	
Before relining	50	15.26 a	4.32	41.98 b	9.26	43.54 b	12.14	0.001*
After relining	50	9.4 a	0.96	45.24 b	2.00	44.9 b	1.73	0.001*
P value		0.001*		0.01*		0.4		

M mean, *SD* Standard deviation, *N* count, *P* Probability level, *Significantly different ($P < 0.05$)

Means with different superscript letters were significantly different

Means with the same superscript letters were insignificantly different

occlusion is adjusted using articulating paper till reaching acceptable simultaneous occlusal contacts. However, this procedure is not accurately reliable for the study of occlusal forces distribution as the accurate analysis that combines time resolution and forces distribution within patient occlusion is not applicable when traditional methods of occlusal assessment are being used (Maruo et al. 2010).

Recently, digital occlusal analysis using T-scan device had been primarily used to evaluate various occlusion parameters. One of the main parameters is the complete dentures occlusal force distribution patterns as it can detect and locate premature contacts and occlusal interference respectively. In this study T-scan had been utilized to evaluate the occlusal force distribution percentage in conventional complete dentures before and after accurate relining procedure.

It is well known that soft liners distribute the occlusal forces uniformly across the denture-bearing area during function leading to limited local pressure points, improved occlusal contact and premature contact point's reduction that usually results from denture movement during function (Rani et al. 2017).

To ensure valid and reliable results, exclusion of inter-examiner variations was insured by making all of the T-scan recordings by the same single examiner who also assessed denture retention and stability. Similarly, only one clinician performed all occlusal adjustments and occlusal parameter recordings for more accurate results (Ibraheem and Hammd 2020).

Regarding anterior area, the study results had revealed that T-scan analysis used for evaluating the percentage of force distribution and for determination of unseen premature contacts that could not be accurately detected
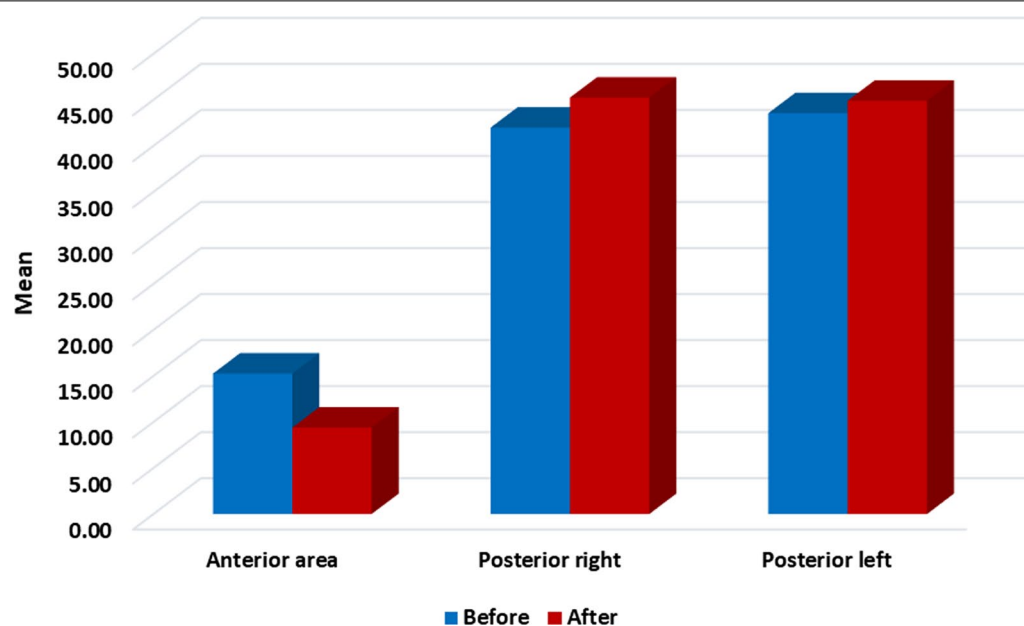
Fig. 5 Bar chart represents occlusal forces percentages before and after denture relining in all study areas

using articulating paper due to mucosal resiliency. Thus, leading to better force distribution patterns on the right and left sides simultaneously after relining and moreover decreasing the anterior share of occlusal load which implies that, the articulating paper may be not sufficient to obtain bilateral occlusal balance in complete dentures.

Furthermore, the right side showed significantly higher percentage of occlusal force after relining which may be due to the role of adhesive in reducing possible displacement and dislodgement of the denture during function, aiding in better fitness, adaptation and also reducing the rotational movement of the denture and accordingly the time needed for food mastication (Maruo et al. 2010).

Conclusions

Within the limitations of the study design, it could be concluded that using digital occlusal analysis (T-scan) and proper denture relining significantly improved the force distribution in initially ill-fitting complete dentures, and further enhanced denture retention/stability ensuring simultaneous occlusal contacts.

Abbreviations
PMMA: Poly-methyl methacrylate; LTSL: Long-term soft lining material.

Authors' contributions
E.I. has made the study design and data analysis. H.E. has made data interpretation and revised the research article. All authors have read and approved the manuscript.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethic approval and consent to participate
This study was designed and approved by the Medical Research Ethical committee (MREC Approval No. 16086) of National Research Centre (NRC), Cairo-Egypt, which is in accordance with Helsinki Declaration of 1975. All patients were informed about the practical steps of this study and signed written approval consent.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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