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Evaluation of occlusal contacts in maximum intercuspation using the T-Scan system

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SUMMARY **Different authors have questioned the reliability of the T-Scan system as a method for registering occlusal contacts. The number of tooth contacts resulting from four bites made in maximum intercuspation was analysed with T-Scan using time moment statistics. The results indicate that (1) the largest number of contacts occur in the molar region (2) variability between subjects is greater than variability within subjects, and (3) it is possible to identify the subject being tested in 90·3% of cases. The T-Scan system has proved to be a reliable method for the analysis and evaluation of occlusal contact distribution in maximum intercuspation.**

Introduction

Both the approaches to the functional analysis of the masticatory system and the concept of occlusion have evolved with time. Reviewing the literature, it can be seen that different, even conflicting, approaches have raised a great deal of controversy as to the diagnosis and treatment of occlusal disorders. To establish a diagnosis of occlusal pathology, however, it is essential to have objective knowledge of the patient's mandibular dynamics, and develop a method that enables the dentist to analyse the functional aspects of occlusion (Laurizten, 1977).

Articulators arose from the need to confront the two opposing arches, thus providing accurate dental reconstructions. Such devices were called antagonizers and their primary purpose was to measure the number of occlusal contacts and position them along the various mandibular excursions. Other methods such as marking paper, occlusal waxes and silicone impressions have not yet proved their efficacy in reproducing occlusal contacts accurately (Dawson & Arcan, 1981; Millstein, 1983; Schelb, Kaiser & Briki, 1985).

Since Arcan & Zandman (1980) developed photo-occlusion, it has been possible to measure the relative force of occlusal contacts. The method, which involves interpreting changes in colour to calculate the intensity of the contact, was criticized by Maness *et al.* (1987) as inaccurate and awkward. Later Maness himself developed a new computerized instrument, the T-Scan* that allowed occlusal contacts to be recorded easily and conveniently. The device was claimed to have great potential for clinical diagnosis and treatment of occlusion as it provided accurate records of the timing and force of tooth contact used as diagnostic variables. Reza & Neff (1991) found that the T-Scan not only enabled the recording of occlusal contacts, but also the analysis of their timing and force level thanks to the sensor's high precision (100%).

The aim of this paper was to study, by means of the T-Scan system, the reproducibility of tooth contact in a position of maximum intercuspation and to verify the reliability of the system as a method of recording occlusal contact.

*Tekscan Inc. Boston, MA. U.S.A.

Materials and methods

The T-Scan allows the quantification of occlusal contact data by registering parameters such as bite length, as well as the timing and force of tooth contact. The system components include a sensor and support, a handle assembly, the system unit, computer software and a printer. The sensor is the key component. When the patient bites on the sensor, the resultant change in electric resistance is converted into an image on the screen. The programme can be operated on two modes; time analysis and force analysis. The former provides information on the location and timing of contacts displaying on the screen with the first, second and third or more contacts in different colours. The latter shows the location of contacts and their relative force in five different shades of colour. Within the force analysis mode, two submodes can be selected, namely the 'instantaneous' which records contacts at specific mandibular positions and the 'sequential' which analyses the contact throughout mandibular movement.

The sample used as the basis for the present study consisted of 18 subjects, 13 males and five females, of ages ranging between 28 and 50 years. The subjects were all students or lecturers at the School of Odontology of the University of Murcia who voluntarily lent their assistance in the study. No selection was made on the basis of age, sex, race or economic characteristics. However, we made sure that the subjects had full dental arches and a healthy periodontal status, were free from pathology, and had not undegone any surgical operations on their temporomandibular joints.

To make the recordings, initially an arch model of each subject was created. The sensor was introduced into the mouth of the subject making sure that the central line of the sensor's support was aligned with the midline of the upper incisors. The subject was then asked to close firmly on the sensor. When the occlusal contacts appeared on the screen, the button on the handle was pressed and the arch model automatically created. The time analysis mode was then selected from the system menu. Unlike the force analysis mode, the time mode does not allow the subject's bite to be seen on the screen, thus eliminating the operator's subjectivity. Afterwards, the subject was asked to bite on the sensor in maximum intercuspation four times. Using the instantaneous force recordings the subjects were previously trained to close in maximum intercuspation. The recordings allowed us to see the subjects's mandibular movements on the screen, train him to bite with maximum intercuspal contacts and check the position's stability. After this training, the subject was able to perform the four bites in a natural unforced way. Recordings were thus made of the lower arch and then printed in two dimensions.

Table 1. Distribution of the mean number of contacts in each patient

Mean number of contacts	Number of patients
8–12	2
12–16	2
16–20	5
20–24	6
24–28	0
28 or over	3

The third molars are not present in the arch model created by the T-Scan, and thus their contacts were not taken into account. Contacts occurring at the interface of two teeth were measured in both zones.

The statistical study was made through the descriptive analysis of variables (tooth contacts) and through analysis of variance (ANOVA), and the latter by comparing each subject's mean number of contacts for each tooth during the four bites in maximum intercuspation.

The discriminant analysis for the statistical study was made with the BMDP7 M software package*. In our study each bite was considered as a 'case' and each patient as a 'group' (4 bites and 18 patients yielded a total of 72 cases and 18 groups in the study). Such an analysis enabled the matching of cases (i.e. bites) with groups (i.e. subjects).

Results

Descriptive analysis of T-Scan-registered variables

For each tooth on the lower arch, except the third molars, the number of contacts from four different bites in maximum intercuspation was analysed in 18 subjects using the T-Scan time analysis mode. The distribution of each patient's mean number of contacts (Table 1) ranged between 8·25 and 30·75, representing the average of all four bites made by all 18 patients. The mean value was 19·43 contacts and the standard

*University of California Press Ltd., U.S.A., 1983.

Table 2. Descriptive analysis of the sample

Tooth	Mean number of contacts	Standard Error	Standard deviation
47	2·79	0·29	2·50
46	1·77	0·19	1·63
45	1·06	0·13	1·17
44	0·76	0·11	0·94
43	0·63	0·10	0·86
42	0·56	0·10	0·88
41	0·61	0·10	0·91
31	0·79	0·11	1·00
32	0·81	0·12	1·02
33	0·70	0·13	1·10
34	0·94	0·10	0·93
35	1·59	0·16	1·42
36	2·38	0·23	1·95
37	3·95	0·33	2·81

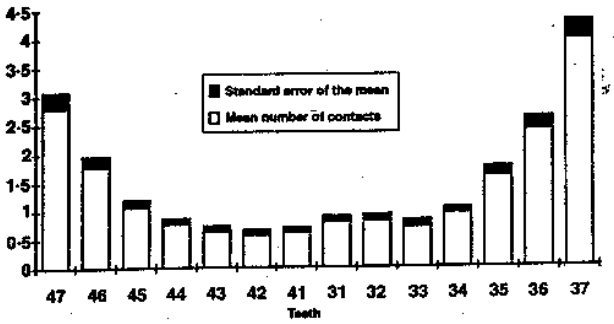

Fig. 1. Standard error of the mean. Mean number of contacts.

deviation 6·08. Eleven of the 18 patients studied had a mean number of contacts between 16 and 24.

The mean and standard deviation of tooth contacts was obtained for each tooth (Table 2, Fig. 1). The mean value was greater than 1·0 for tooth numbers* 47, 46, 45, 35, 36 and 37, tooth number 37 registering the largest number on average, with a mean value of 3·95 and a standard deviation of 2·81. Teeth with the lowest values were numbers 41 and 42, with a mean value of 0·61 and 0·56 and a standard deviation of 0·91 and 0·88, respectively.

Analysis of variance of T-Scan-registered variables

The analysis of variance was made by comparing each subject's mean number of contacts for each tooth during the four bites in maximum intercuspation. The results

*F.D.I. notation.

Table 3. ANOVA of the comparison between patients

Tooth	'F' Snedecor g. l. = 17/55 *	$P < 0·05$
47	9·10	$P < 0·005$
46	4·24	–
45	3·32	–
44	11·20	–
43	4·58	–
42	4·24	–
41	2·92	$P < 0·01$
31	7·57	$P < 0·005$
32	3·70	–
33	5·95	–
34	4·93	–
35	4·73	–
36	5·65	–
37	11·21	–

*, degrees of freedom.

obtained show that variability between subjects is significantly greater than variability within subjects ($F > 2$) (Table 3) which shows the reliability of the values obtained by the T-Scan, being able to differentiate between individuals. Teeth with the largest variability between subjects were numbers 37 and 44, which was 11·20 and 11·21 times, respectively, the variability within subjects. Teeth with the lowest variability values were numbers 41, 45 and 32.

Discriminant analysis of T-Scan-registered variables

The discriminant analysis showed that it was possible for each subject to be identified and distinguished from the others ($F < 2$). This is shown by the fact that the T-Scan was able to assign all four bites to the same patient in 90·3% of cases (Table 4).

Discussion

The findings of this study show that, in maximum intercuspation most subjects had a mean number of contacts between 16 and 24 (Table 1). However, while their absolute values may vary according to the method of registration used (Takai *et al.*, 1993), it is important to assess the number of contacts as some authors have reported the existence of a relationship between a low number of contacts and the appearance of craniomandibular disorders (Bakke, 1993).

The largest number of tooth contacts for the sample studied occur in the molar (teeth numbers 37, 47, 36

Table 4. Percentage of correct identification of subjects tested

Subjects	Correct percentage
1	100
2	100
3	100
4	100
5	100
6	100
7	75
8	100
9	50
10	100
11	100
12	100
13	75
14	50
15	100
16	100
17	100
18	75
Total	90·3

and 46) and premolar regions (Table 2). These results are consistent with those of Maness & Podoloff (1989). These authors also found a symmetrical distribution of contacts on the left and right sides of the dental arch, a finding later confirmed by the experiments of Athanasiou, Melsen & Kimmel (1989) with photo-occlusion.

In the present work, the largest number of contacts corresponded to the second molars (47, 37), although their respective numbers were not identical, the highest value being that for the second left molar. These data agree with those of Koriot (1990), who found the number and location of tooth contacts to be asymmetrical in the majority of the subjects studied.

The results indicate that variability levels between subjects in maximum intercuspation were well above the levels of intra-subject variability (Table 3). T-Scan data also allowed us to identify a subject in 90·3% of the cases (Table 4). In our analysis we have found seven of the 14 variables to be more discriminant, namely teeth numbers 47, 44, 42, 31, 35, 36 and 37. This points to the existence of a single pattern of mandibular closure repeated by each subject when performing a maximum intercuspation, and seems to strengthen the idea that some teeth have greater reproducibility than others and therefore enough discriminant capacity to allow comparative studies to be carried out.

With regard to the sensor's reliability, our results disagree with those of Harvey, Hatch & Osborne (199?), who finds the sensor cannot detect occlusal interferences if used more than twice, and Patyk *et al.* (1989) and Setz & Geis-Gerstorfer (1990) who consider the sensor to have scarce resolution capacity and reliability. Also Yamamura & Takahashi (1990) reported the existence of non-sensitive areas on the sensor's surface leading to unreliable reproduction of occlusal contact. Our opinion differs from the above in that although the same sensor was used throughout the four bites, in most cases the system was able to match the bites with the individual who made them. We do not know, however, when the sensor becomes inefficient and therefore it may be interesting to determine, by use of discriminant analysis, the number of bites beyond which the sensor loses efficacy.

Our findings also contradict those of other authors with regard to the reproductibility of the topography of contacts and their time sequence (Dees *et al.*, 1992). In our study, the T-Scan was able to assign each bite to its group of origin (subject) after the number and distribution of contacts in that bite were known, even with data from as few as seven teeth.

It follows from the findings of this work that the T-Scan is a reliable method for measuring the number of tooth contacts and studying their distribution in maximum intercuspation, and as reported by Lyons, Sharkey & Lamey (1992), it is also a convenient (as well as an objective) method for both the patient and the operator. It is our opinion that the T-Scan could open up the way to new identification methods based on the features of tooth contacts, thus completing the wide range of available techniques; sweep microscopy, image analysers, and genetic markers, which require highly complex laboratory procedures.

Conclusions

1. The results obtained by T-Scan show that variability between subjects is significantly greater than variability within subjects which shows the reliability of the values obtained by the T-Scan, being able to differentiate between individuals.
2. T-Scan data also allowed us to identify a subject because T-Scan was able to match all four bites with the subject who made them in 90·3% of the cases.

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