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The T-SCAN System in Evaluating Occlusal Contacts

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Background: Normal occlusal and articulation relations between the jaws ensure equal distribution of occlusal forces during mastication. A T-SCAN system allows these relations to be measured dynamically during the articulation cycle.

Aim: To evaluate the T-SCAN III system in measuring and assessing the forces of occlusal contacts and their digital presentation.

Patients and methods: Thirty students aged 19 - 22 years were examined. Of these only one matched the study criteria:

- intact dentition;
- without or with class I fillings in teeth 36 or 46;
- Angle's class I jaw relation

We used a computerized occlusal analysis system T-SCAN in the study. It comes with a registering sensor for the occlusal contacts, a module for transmitting the signals to a computer, and conversion software to generate images on a computer screen.

Results: We evaluated the system's capabilities in registering the occlusal contacts during mastication on an occlusion film and the occlusal forces using a digital display.

Conclusion: The T-SCAN system provides the only accurate way to determine and evaluate the time sequence and force of occlusal contacts by converting the qualitative data into quantitative and displaying them digitally.

BACKGROUND

Normal occlusal and articulation relations between the jaws ensure balanced distribution of the generated forces in them during mastication. Any premature occlusal contacts and occlusal-articulating blockages cause occlusal traumas which induces changes in the tooth-supporting tissues (the mucosa, periodontal tissues, and bone), in the masticatory muscles and the temporomandibular joint.[1]

There are a variety of occlusal analysers used to register the occlusal-articulation relations. In dental practice articulating paper has been established as the most commonly used diagnostic tool to identify contact points between the maxillary and mandibular teeth. The paper can readily highlight occlusal contacts, but cannot accurately quantify their intensity and measure the magnitude of the generated occlusal forces. The size of the mark area on the articulating paper is representative of how heavy the occlusal load is.[2] Saad, Weiner and Ehrenberg argue that the interpretation of the marks on the paper is subjective and therefore inaccurate because identical occlusal loads correspond to markings of different intensity.[3] This conclusion is supported by Millsterin and Maya.[4] To avoid the subjectivity in the interpretation of the articulation paper markings dental research introduced the T-SCAN computerized occlusal analysis system.[5]

Maness in 1987 developed the T-SCAN system for computer occlusal analysis because it yields measurements in real time of occlusal forces recorded using the T-SCAN intraoral sensor.[6]

In 1992 Lyons MF, Sharkey SW, Lamey PJ found, in a clinical study evaluating the T-SCAN system for measurement of occlusal forces, that the system was unable to measure them accurately although it can still serve as a useful clinical tool.[7]

In Bulgaria, Kalachev conducted a number of studies on the occlusal-articulation relation in intact dentition during articulation with T-SCAN II

elucidating the relationship between occlusal load and periodontal stress.[8]

The first generation (G1) sensor developed in 1987 has undergone many changes in its design and improvement of its registration capacity based on a number of clinical studies.[9] The last generation sensor developed by the same company is the high definition (HD) sensor which is far more sensitive and thinner than the previous sensors.[10] Two sizes of this sensor are now available on the market: a small size accommodating dental arches up to 58 mm wide, and a large one that can accommodate up to a 66-mm-wide dental arch.

The original design of the T-SCAN system has been repeatedly modified and improved both in the software and hardware until the present day version of the system - T-Scan III. The software uses graphical interface.[11] The programme processes the data and shows them in full-colour 3D or 2D graphics. In the 2D graphics the generated occlusal contacts are visualised as contours or cellular images on the dental arch. There is an optional feature that allows the left and right sides to be shown in different colour codes (green on the left and red on the right) with the respective occlusal forces displayed below. The dentition can also be divided in anterior and posterior halves giving as a result 4 segments to analyse.

In the 3D graphics, the registered contacts are visualised as columns of different color and height quantifying the intensity of the forces generated on occlusion. The magnitude of occlusal load is colour coded the maximum being shown in red and the minimum force in blue **(Fig. 1)**.

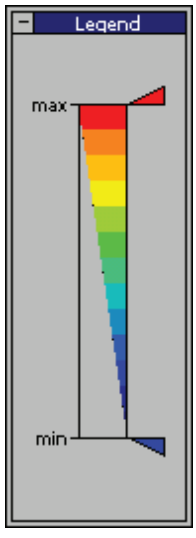


Figure 1. Color scale for evaluation of occlusal contacts.

T-SCAN III analyses the order of the occlusal contacts while simultaneously measuring the force percentage changes of those same contacts, from the moment the teeth fist begin making occlusal contact all the way through to centric intercuspation.

It shows the abnormal forces leading to trauma or pain in every tooth in the dental arch. This helps to balance the forces on both sides of the dentition.[12]

Kerstein RB et al. consider the T-SCAN III system to be a highly accurate technique to study and analyse the occlusal and articulation relations.[13] Koos supports the view that the system has certain advantages in terms of accuracy, reproducibility and visualisation of the dental arches.[14]

AIM

The aim of the present study was to evaluate the T-SCAN III system in quantifying the occlusal contacts.

PATIENTS AND METHODS

Thirty students (17 male and 13 female) were recruited in the study from the Faculty of Dental Medicine, Plovdiv. Ten of these were 19 years old, 11 - 20 years old, 5 - 21 years old, and 4 - 22 years old. The mean age of the study contingent was 27.3 yrs.

The students were examined checking specifically for the following:

- intact dentition,
- no fillings or one class I filling of teeth 36 or 46,
- Angle's class I jaw relations.

Only one subject of the study contingent (T. P.) met these criteria.

The recording sensor, which comes with the system, consists of two layers of conductive grid encased into highly pressure-sensitive plastic foil. It is U-shaped as one of its parts goes into a scanning handlebar and the other one, dental arch-shaped, registers the occlusal and articulation relations **(Fig. 2)**.

We conducted the study using the T-Scan III device consisting of a sensor registering occlusal contacts, a data transferring module linked to a computer, a software programme to send data to the computer and visualise them on the monitor.

These three when assembled are referred to in the literature as T-SCAN system.

The recording procedure is performed in strict conformity with the manufacturer's instructions

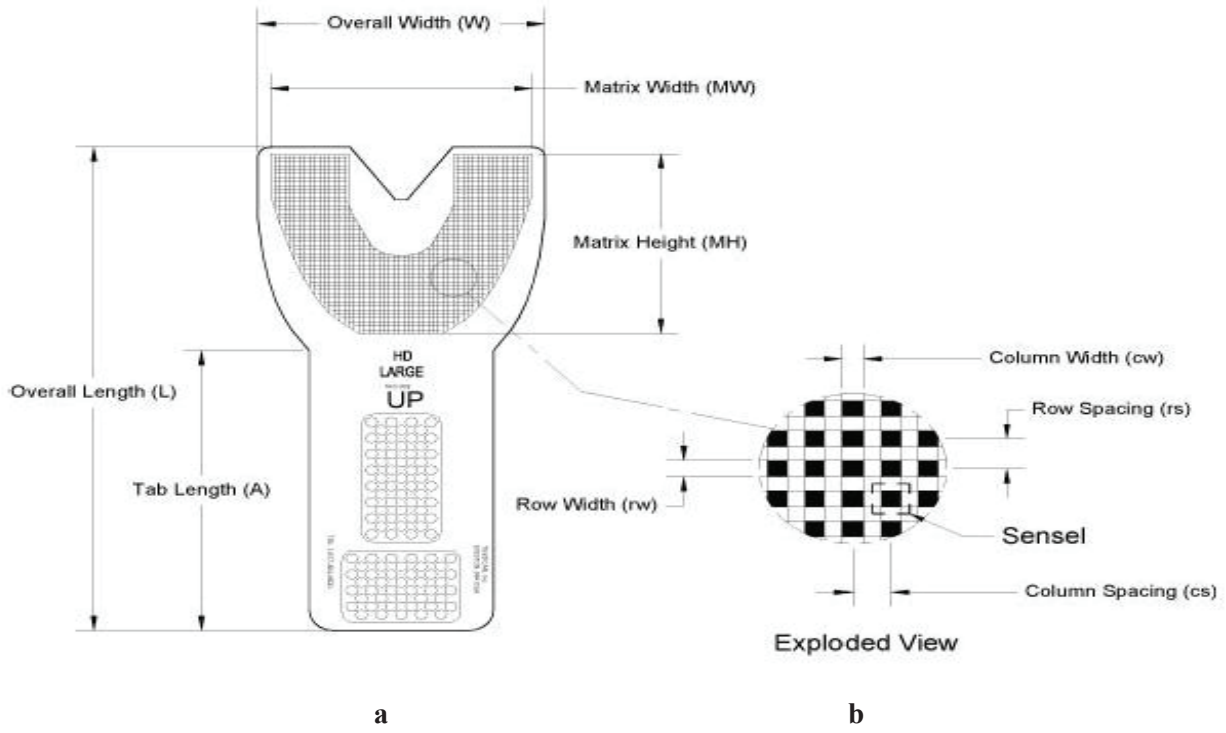


Figure 2. T-SCAN recording sensor: a) full view; b) exploded view of a segment

of using the device to register occlusal contacts. The patient is seated on the dental chair with the lower and upper parts of his body positioned at an angle of 90º. We used a small 100-micron-thick HD sensor, which is inserted in the sensor handle connected to the scanning handlebar **(Fig. 3)**.

The recording sensor is inserted intraorally between the dental arches so that the central mark is positioned between the central incisors of the patient **(Fig. 4)**.

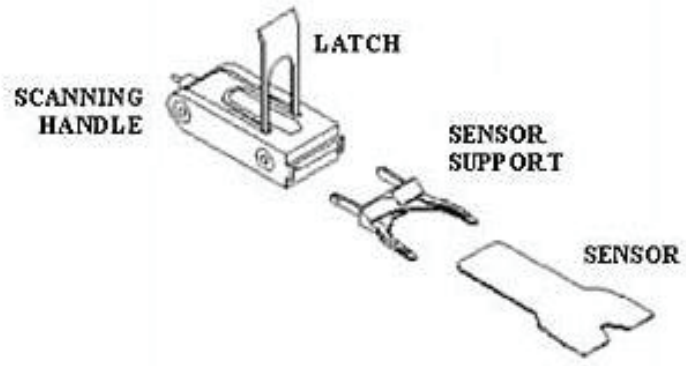


Figure 3. The T-SCAN III recording handle and sensor.

Figure 4. Proper positioning of the T-SCAN registering sensor.

Recording starts with pressing the button on the handlebar; the patient is instructed to occlude firmly to complete intercuspation. We did 7 to 10 measurements of the occlusion recorded on occlusal films. One of the films is analysed (duration 2.019 seconds) by dividing it into 0.02-sec-long time frames to accurately describe the force changes during occlusal contacts.

RESULTS

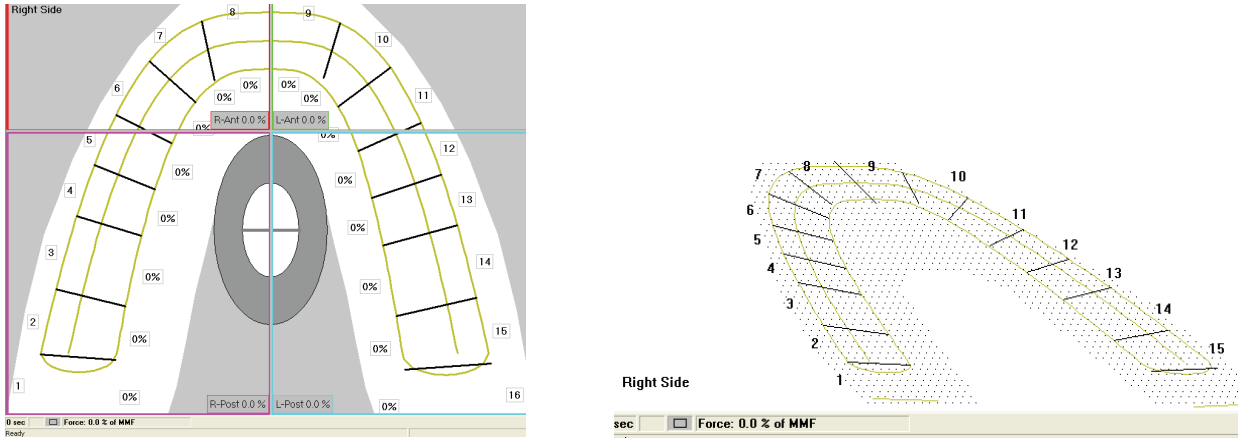
Table 1 presents the results showing the occlusal forces (in percentages) from first tooth contact through to complete centric intercuspation.

The force changes in occlusal contacts are presented in graphical form for each segment during registration of the occlusion **(Figs 5-9)**.

DISCUSSION

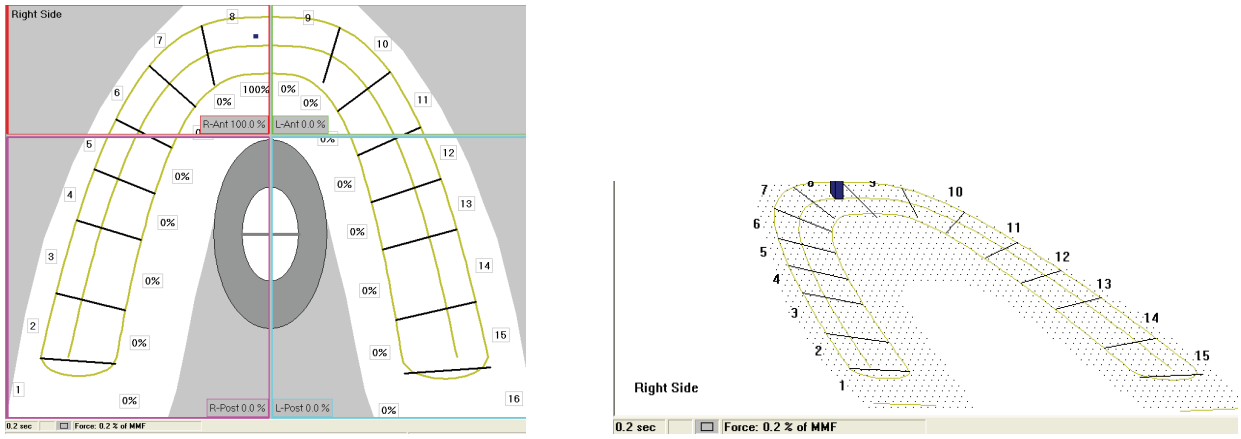
The contingent we studied suggests that the number of subjects with intact dentition decreases drastically with age while the number of fillings increases.

The time elapsing from first contact until centric intercuspation is extremely short (1 to 3 sec). The first occlusal contact occurs in the area of the first right central incisor at 0.2 sec with the force level in the left anterior segment at 100%. By 0.46 sec. occlusal contacts occur only in the anterior segments, which depends on the condition of the dentition and the temporomandibular joint, because when the mandible is closed the teeth contact first edge-to-edge. The first occlusal contacts in the posterior segments occur at 0.46 sec. with minimal force level. Then the forces in



a **b**

Figure 5. Beginning of registration – no occlusal contacts. a) 2D view; b) 3D view.



a **b**

Figure 6. First contact: a) 2D view; b) 3D view.

Table 1. Changes of the occlusal force for each time frame

No	Time frame	Occlusal force (%)				
		Maximum occlusal force	Right anterior segment	Left anterior segment	Right posterior segment	Left posterior segment
1	0.2	0.2	100	0	0	0
2	0.22	0.3	100	0	0	0
3	0.24	0.3	100	0	0	0
4	0.26	0.9	77.3	22.7	0	0
5	0.28	0.7	71	29	0	0
6	0.3	0.4	55.9	44.1	0	0
7	0.32	0.2	100	0	0	0
8	0.34	0.2	100	0	0	0
9	0.36	0.9	76.5	23.5	0	0
10	0.38	1.3	80	20	0	0
11	0.4	2.2	72.3	27.7	0	0
12	0.42	4.3	64.5	35.5	0	0
13	0.44	9.1	49.7	42.7	0	0
14	0.46	15.8	37.3	46.2	1.7	14.8
15	0.48	23.8	28.2	40.1	6.6	25.1
16	0.5	38.3	20	24.5	13.7	41.9
17	0.52	53.3	15.8	18.7	15.5	50
18	0.54	66.7	13	15.2	18.9	52.9
19	0.56	75.2	11.9	14	20	54.1
20	0.58	81.6	11.1	13.1	21.6	54.2
21	0.6	85.5	10.9	12.5	22.3	54.3
22	0.62	90	10.9	11.9	22.5	54.7
23	0.64	91.9	10.8	11.7	22.6	54.9
24	0.66	93.5	10.7	11.6	22.7	55.1
25	0.68	94.9	10.6	11.4	22.7	55.4
26	0.7	95.7	10.5	11.3	22.7	55.5
27	0.72	96.7	10.4	11.2	22.9	55.4
28	0.74	97.7	10.6	11.1	22.8	55.4
29	0.76	98.1	10.6	11.1	28.8	55.5
30	0.78	98.7	10.8	11.1	22.8	55.4
31	0.8	98.9	10.8	11	23	55.2
32	0.82	99.1	10.5	11	23.2	55.3
33	0.84	99.2	10.5	10.9	23.3	55.3
34	0.86	99.3	10.6	10.9	23.1	55.5
35	0.88	99.4	10.6	11	23.2	55.2
36	0.9	99.5	10.6	11	23.6	54.9
37	0.92	99.3	10.6	11	23.5	55
38	0.94	99.3	10.6	11	23.7	54.7
39	0.96	99.3	10.6	11	23.7	54.7
40	0.98	99.2	10.6	10.8	23.7	54.8
41	1	99.2	10.7	10.8	23.7	54.8
42	1.02	99.5	10.7	10.8	23.9	54.6
43	1.04	99.8	10.6	11	23.8	54.6
44	1.06	99.7	10.6	11	23.7	54.6
45	1.08	99.6	10.7	11	23.7	54.6
46	1	99.8	10.7	11	23.7	54.6
47	1.12	99.8	10.7	11	23.7	54.6
48	1.14	99.7	10.7	11	23.7	54.6
49	1.16	99.8	10.7	11	23.7	54.6
50	1.18	99.9	10.7	11.1	23.8	54.5
51	1.2	99.5	10.7	10.9	23.8	54.8
52	1.22	99.2	10.7	10.9	23.8	54.6

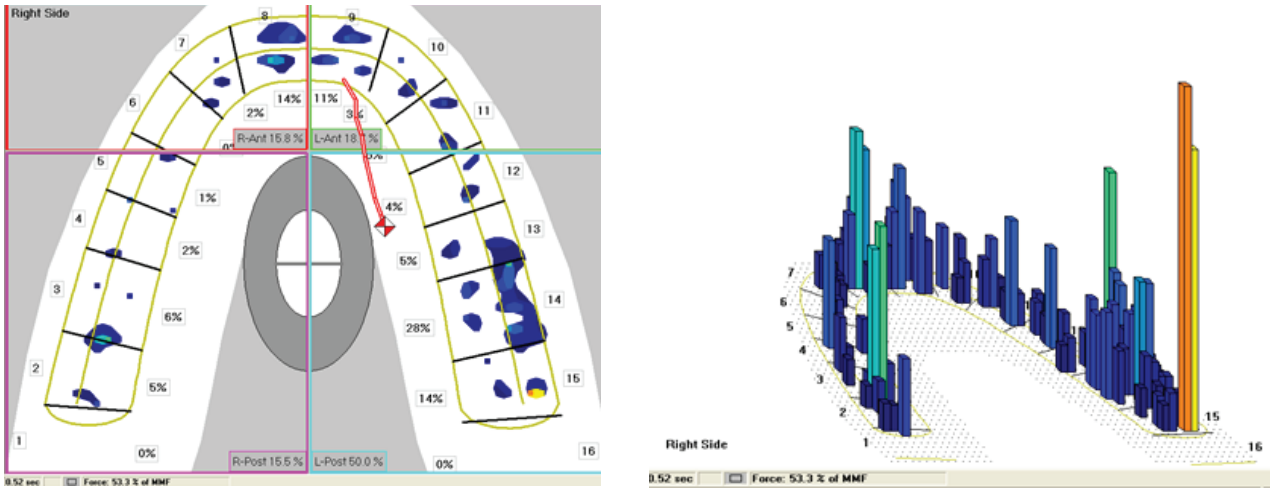


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Figure 7. Contacts at 50% of maximum force: a) 2D view; b) 3D view.

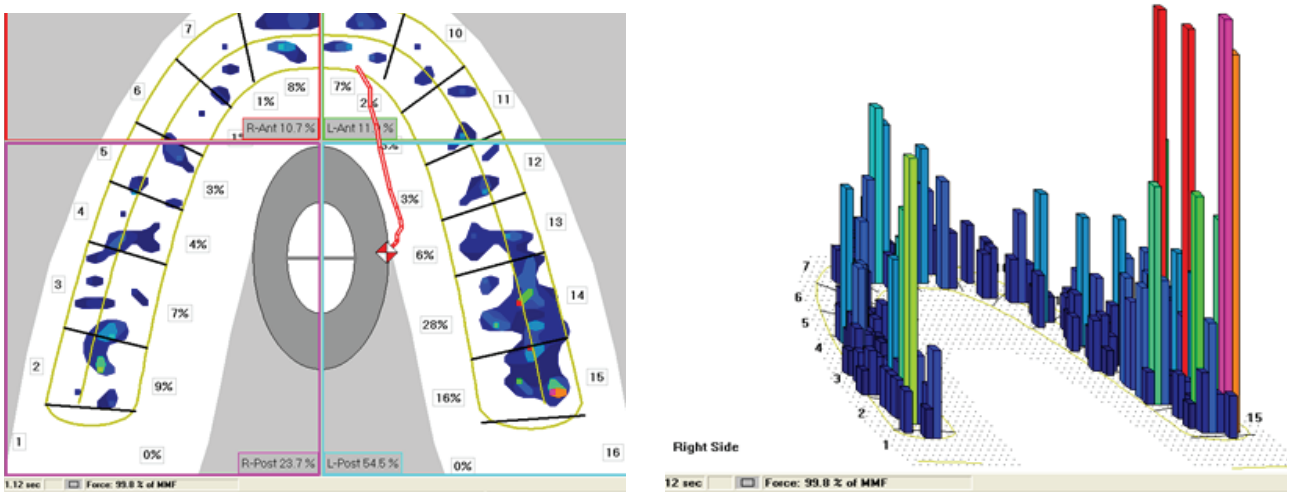

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Figure 8. Contacts at maximum force: a) 2D view; b) 3D view.

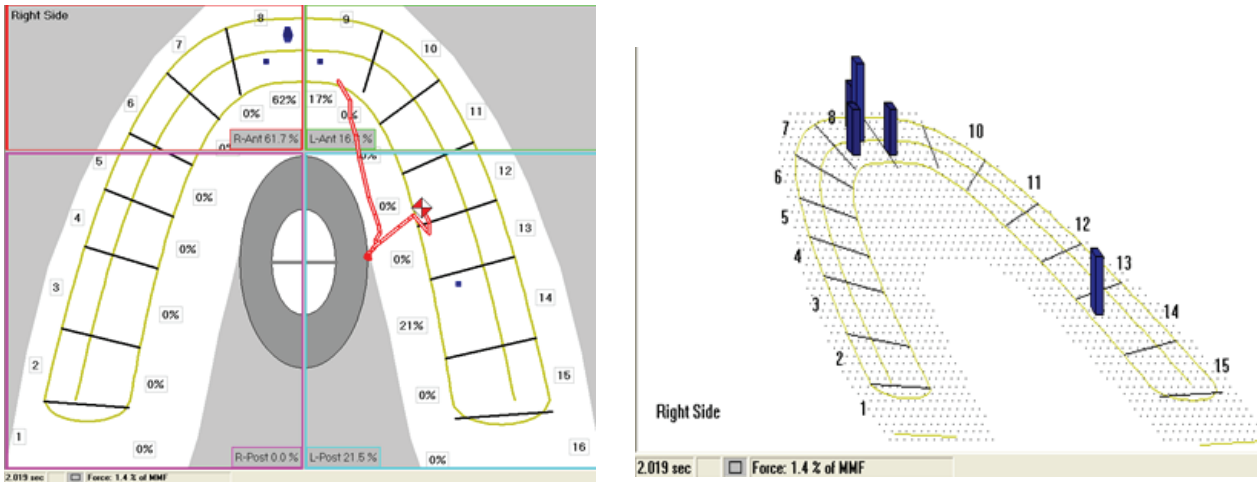

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Figure 9. Contacts at decreasing occlusal force: a) 2D view; b) 3D view

the anterior segments begin to decrease and those in the posterior segment increase.

When the occlusal force is at 50% of the maximum, the forces in the anterior segments are almost similar in magnitude, although those in the posterior segments are considerably higher and predominantly so in the right posterior segment. We can observe the changes occurring in the occlusal forces until centric intercuspation in their dynamics – the reach a maximum of 99.8% at 1.12 seconds. The occlusal forces generated in the anterior segments change just a little and are lower than those in the right posterior segments. The forces on the left posterior segment are twice as high as those in the right posterior segment. Then the occlusal forces begin to gradually diminish because of the decrease of the number of occlusal contacts.

The mean levels of forces in the different segments are as follows: right anterior segment (RAS) - 29.33%, left anterior segment (LAS) - 14.86%, right posterior segment (RPS) - 16.34%, left posterior segment (LPS) - 39.43% **(Fig. 10)**. Comparing these data it is easily seen that the left side of the dentition bears greater load than the right side. Also there is obvious imbalance of occlusal forces between the two halves of the dentition. The T-SCAN system helps in assessing the occlusion and in balancing the occlusal forces by quantitatively measuring them.[12] To achieve perfect occlusion all posterior teeth should make contacts simultaneously and all occlusal contacts should be balanced.[15]

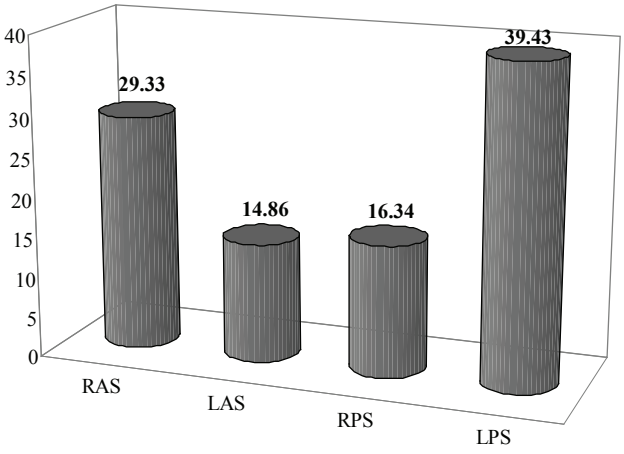


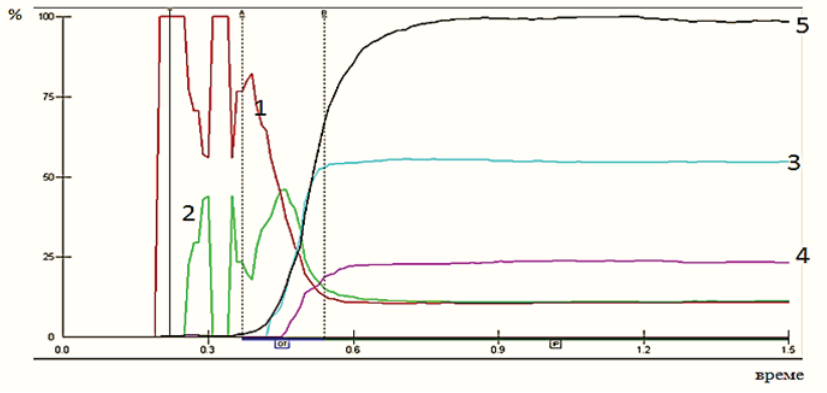
Figure 10. Average levels of occlusal forces (%) for each segment of the dentition.

The force generated in occlusion is dynamic in nature as it changes with time and can be plotted against time in a graph **(Fig. 11)**.

The software programme of the system provides better visualisation of dental arches[16] making it much more informative than other methods for occlusal contact registration.[5,17,18] T-SCAN III allows fast and accurate registration and analysis of occlusal-articulation articulation analysis.[19]

CONCLUSIONS

The T-SCAN system provides a very accurate way of determining and evaluating the time sequence and force magnitude of occlusal contacts by converting qualitative data into quantitative parameters and displaying them digitally. Using the system, multiple corrections of imbalanced forces can be performed for every segment of the dentition. The system is a useful clinical method that eliminates a biased subjective evaluation of the occlusal and articulating relations on the part of an operator.



Legend: 1 - Right anterior segment, 2 - Left anterior segment, 2. Left posterior segment, 3. Right posterior segment, 5 – Maximum force

Figure 11. Graphic display of changes in percentage of load over time.

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Возможности системы T-СКАН III для измерения и оценки силы контактов

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Введение: Нормальные окклюзионно-артикуляционные взаимоотношения между двумя челюстями обеспечивают равномерное распределение окклюзионных сил во время жевательного акта. Система T-СКАН III предоставляет возможность для регистрации данных взаимоотношений в их динамике во время артикуляционного цикла.

Цель: Демонстрировать возможности системы T-СКАН III при измерении и оценке силы контактов и их цифровое представление.

Материал и методы: Было обследована 30 студентов в возрасте 19 - 22 лет, среди которых один отвечал установленным нами критериям: наличие интактного соединения зубов; без или с обтурацией I класса зубов 36 или 46; соотношение между двумя челюстями - I-класс по Энглю.

Исследования были проведены при помощи медицинского диагностического аппарата T-СКАН, состоящего из: сенсора для регистрации окклюзионных контактов, связывающего модуля для ввода сигналов в компьютер, программы для преобразования сигналов в изображение на мониторе.

Результаты: Результаты исследования демонстрируют возможности системы T-СКАН III для: регистрации и записи окклюзионно-артикуляционных взаимоотношений во время артикуляционного цикла на т. н. плёнку окклюзии и оценки сил, возникающих во время контактов посредством цифрового представления.

Заключение: Система T-СКАН III является единственным объективным методом для определения и оценки последовательности и силы окклюзионных контактов путём преобразования качественных измерений в количественные показатели с последующим цифровым представлением.