

# A STUDY ON THE ERGONOMICAL WORKING MODALITIES USING THE DENTAL OPERATING MICROSCOPE (DOM). PART I: ERGONOMIC PRINCIPLES IN DENTAL MEDICINE

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## REZUMAT

Un mod de lucru cât mai confortabil, mai simplu și mai eficient a fost dintotdeauna o dorință universală a omului. Liderii de opinie, prin realizarea de proiecții, au determinat dezvoltarea unei științe cu un caracter multidisciplinar. Ergonomia dentară s-a dezvoltat ca o ramură a ergonomiei generale, împreună cu diversificarea instrumentelor și echipamentelor dentare, în același mod cu creșterea gradului de complexitate al tehnicilor curente de lucru și a posibilităților de evaluare a activității. În aparentă contradicție cu ideea de simplificare a muncii, ergonomia dentară stabilește reguli și standarde care trebuie asimilate, aplicate și individualizate de fiecare dentist în parte; ele sunt valabile pentru toate specialitățile dentare (cu particularități pentru fiecare). Concept de natură duală, cântărind inițial efortul depus față de beneficiile câștigate (eficiența activității), ergonomia dentară își modifică propriul înțeles în societatea actuală prin îmbunătățirea calității vieții și prevenirea factorilor ocupaționali, cu beneficii atât pentru echipa dentară, cât și pentru pacient. Microscopia dentară, cu întregul echipament, accesorii și metode de lucru, aduse în panoplia terapeutică a medicinei dentare, nu face nici o excepție de la imperativele ergonomice ale stomatologiei. Deși relativ recent utilizată în terapia dentară modernă, microscopia dentară este intens folosită în specialități dentare ca endodontia, microchirurgia parodontală, stomatologia estetică, etc. Ca rezultat, activitatea îndelungată la microscopul dentar are ca și consecință solicitarea corpului, pe de o parte. Pe de altă parte, microscopul dentar - ca parte integrată a echipamentului terapeutic și diagnostic din cabinetele dentare - este considerat ca făcând parte din circuitele operatorii. Ambele motive impun stabilirea unor criterii de activitate ergonomică, care devine obiectul unei analize științifice.

## ABSTRACT

A more comfortable, simple and more efficient work is a universal desire. No wonder this man's natural tendency, by abstraction, determined the development of a science of a multidisciplinary character. The dental ergonomics developed as a branch of the general ergonomics, together with the diversification of the dental instruments and equipments, as well as with the increase of the complexity degree of the current working techniques and possibilities to assess the activity. In apparent contradiction with the idea of simplifying the work, the dental ergonomics establishes rules and standards that have to be assimilated, applied and individualized by each dentist; they keep their validity in all the branches of the dental specialty (with particularities to each specialty). A concept of a dual nature, initially weighting the effort made and the benefits achieved (efficiency of the activity), the dental ergonomics modifies its own meaning in the today society, towards the improvement of the life quality and prevention of the occupational conditions, with benefits both for the dental team and for the patient. The dental microscopy, with its whole equipment, accessories and working methods brought in the therapeutic panoply of the dental medicine, does not make any exception from the ergonomic imperatives of the dental profession. Although relatively recent used in the modern dental therapy, the dental microscope is used intensely in dental specialties such as endodontics, periodontal microsurgery, dental esthetics, etc. As a result, working for a long time with the dental microscope has as a consequence solicitations of the body, on one hand. On the other hand, the dental microscope - as an integrated part of the therapeutic and diagnostic equipment in the dental office - is considered to be part of the operating circuits. Both reasons imposed the establishment of ergonomic working criteria, which became the object of a scientific analysis.

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## DEVELOPMENT AND SIGNIFICATION OF APPLYING ERGONOMIC PRINCIPLES IN DENTAL MEDICINE

The possibility to develop complex technical systems in the first part of the XXth century and the study of the workers' conditions led to the reconsideration of the criteria regarding the manufacture of the equipment to be used in different fields for an efficient-effort balance.

Ergonomics, as a discipline, has its formal beginnings immediately after the Second World War. The studies of efficiency, carried out by psychologists

on pilots, radar and sonar operators in Great Britain during the war and immediately after it, showed the importance of designing technologies that should adapt sizably, statically and dynamically to the human body and that should stimulate the physical and mental possibilities of the human. The term of ergonomics (Greek: *ergon* - work, *nomos* - laws) was adopted on February 16, 1950 to define this discipline of applied study regarding the technological design oriented towards the increase of human performance (the term of ergonomics was first mentioned in Poland, in 1857, in Professor's Wojciech Jastrzebowski's publications on researches on the work efficiency). The first scientific society for studies on work was founded in Great Britain in 1949 (today The Ergonomics Society), followed by the American society called US Human Factors Society, in 1957. As the study of ergonomics generated a global interest, the International Society of Ergonomics was created in 1959 to coordinate the international activities.

The modern ergonomics is an interdisciplinary applied science that studies the optimization possibilities of the man-machine system design by knowing the human's physical and mental possibilities and limits, his capacity to learn, the factors generating errors, the work the physiology, the human behavior as an individual and within a team, the managerial possibilities, the organizational culture (interdisciplinary study of anatomy, physiology, psychology, management) and the technical and designing possibilities (engineering, design).<sup>1</sup> An objective definition was given by Chapanis (1985) which referred to ergonomics as the discipline that "discovers and applies information on behavior, human abilities and limitations, on characteristics of the equipment, instrument, system design, on profession requests as well as characteristics of the working environment necessary to its productive, safe, comfortable and efficient use by man". In the field of the dental medicine, Kilpatrick described working modalities using the economy of movements in his book "Work Simplification in Dental Practice" (1964), insisting on the aspect of the efficient organization of the dental practice.<sup>2</sup> Fritz Schon and Karlheinz Kimmel published in 1968 "Ergonomics in the dental consulting room", a book last edited in 2001. In Romania, Professor Ioan Gall (*Practica stomatologica*, 1970) wrote some notions of ergonomic organization of the working space. The study of the dental ergonomics was introduced in the university curriculum of the most universities with dental schools in Romania in 2003.

More oriented towards the second component of the term (comfort = lack of diseases), the current

literature in the field of dental ergonomics includes three categories of topics:<sup>3-10</sup>

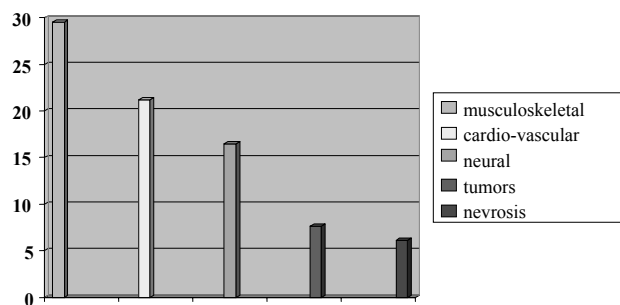
1. Musculoskeletal disorders; disorders and associated risk factors; psychological-social disorders and associated risk factors;

2. Accessibility and efficiency of the ergonomic interventions.

3. Applied discipline, the ergonomics identifies the problems using specific studies, establishes criteria of elements of design and organization of the activity, then it reassesses the modifications intervened in practice (feed-back).

## MUSCULOSKELETAL DISORDERS (MSD). DETERMINING FACTORS

The main occupational conditions of the dentists have been described in the literature in the sixth decade. Among them, the musculoskeletal disorders have the highest incidence in this occupational group.<sup>11</sup> (Fig. 1)



**Figure 1.** The incidence of the main occupational conditions in dentists (after Murphy)<sup>11</sup>.

These conditions are described in the literature under several names that refer either to their definition as such, or to their cumulative character or to the determining causes as follows:<sup>3</sup>

- Work-related musculoskeletal disorders (WR-MSD);
- Conditions due to repetitive tasks (RSI);
- traumas with cumulative effect (CTD).

The name under which they are described is not important, as they all refer to all the disorders regarding bones, muscles, joints and nerves – for example conditions affecting the backbone, the carpal tunnel syndrome, the tendinitis etc.

Favoring factors of MSD are:<sup>12-18</sup>

1. Repetitive movements: they refer to the same movement or a succession of movements made at regular intervals or continuously for a long period of time. They are associated with a high degree of precision, and carried out on very restricted areas.

2. Uncomfortable position (operator's and patient

incorrect position): a postural position of minimal muscular requirements to all levels (neutral position), either in the standing work position or in the sitting one. Postures that differ from this one imply an increased muscular strain up to certain levels.

3. Long periods of activity over which the repetitive movements or the uncomfortable postures are maintained.

4. Lack of breaks in activity or irregular breaks (lack of muscular relaxation).

5. Powerful movements associated with hand grasping of instruments.

6. Vibrations – they can affect particular parts of the body, e.g. the hands, when using mechanical equipment which produces localized vibrations. Vibrations can be also exerted on the whole body, e.g. workers with drilling pneumatic equipment.

7. Uncomfortable surrounding environment – e.g. increased temperature and humidity, excessive noise, improper lightning.

8. Stress due to the faulty organization of the activity (e.g. time pressure, answer to the patient's anxiety etc.).

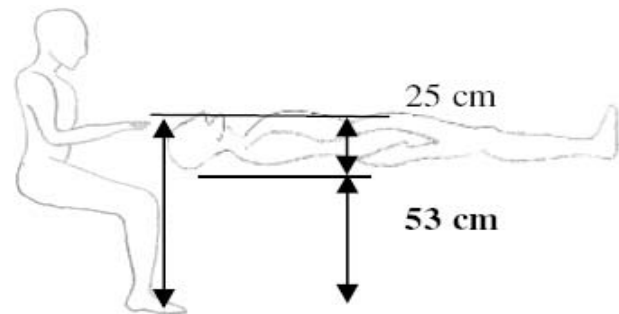
## **DENTIST'S MAIN BENCHMARKS IN REDUCING THE OCCUPATIONAL DISORDERS**

The movements of the dentist within the dental office and the particular movements he/she could make during a dental procedure (access to instruments, adjustment of the light source, change of work positions, etc.) are taken into account from ergonomic point of view. The patient's position and the organization of the instruments and equipments are established in order to maintain a correct working position.

The correct working posture is the starting point of all other ergonomic determinations. Therefore, the dental chair of the future will have to provide the comfort the physician needs during his activity. The main measurements necessary to carry out for each component of the chair are: the plane surface, the back and leg of the chair. We can also establish the dentist's maximum space of access around the dental chair (the total arm spreading necessary to adjust the working instruments/light source).

Ergonomic researches established the correct position the dentist' body should have while working: the chair has to be adjusted in such a way the feet should lean on the floor (the angle formed between the thigh and the lower part of the foot should be of

minimum 90°), the spinal column has to be as straight as it possible, the physiological lordosis of the lumbar spinal column must be maintained and the shoulders must form a straight, perpendicular line on the floor together with the hips. The elbows must be beside the body, bent to 90°.12 (Fig. 2)



**Figure 2.** Ergonomic dimensional standards of the dentist's body in relation with the body of the patient.

## **REGULATIONS AND STANDARDS OF OPERATING DENTAL EQUIPMENTS**

The identification of a many of the work-related musculoskeletal disorders (mostly related to the working posture and to the man-equipment interface) led to the establishment of the ISO 6385 and ISO 11226. They set the criteria on the orientation in designing the equipment used in the dental practice. It also contains several "General Principles of Guiding", representing a selection of relevant aspects.<sup>9</sup>

The standard ISO 6385 "Ergonomic Principles of Designing Equipment" contains the following essential directions:

- Designing the working space and equipment;
- Designing in relation with the posture, muscular force and body movements;
- Designing the working environment.

The standard ISO 11226 "Ergonomics – assessment of working static postures" has the following orientations:

- To maintain a relaxed posture;
- To alternate the working postures (dynamic work);
- To practice sports and exercises to strengthen the muscular girdle.

## **ISO BASIC CONCEPTS**

As a consequence of the international standardization regarding the design of the working units, the ISO basic concepts for the dental units represent a classification of the working ways based on

a ergonomic relation between the operator and his/her working environment. The varieties of arrangements as well as the design of the unit allow an individual style of working to be adopted in ergonomic conditions. The result of this report - different within each concept – is the increased efficiency of the activity as well as the operator's increasing comfort. The characteristics refer both to the different placing for each category of equipment within the physiological working space (instrument trays, handpieces, aspiration system and mobile sub-units) and to the various designs of the unit itself. In doing this, the system of the clock display for orientation (the patient's vertex at 12 o'clock and the chin at 6 o'clock) is used.<sup>13</sup>

### **The choice of working ways using the ISO standards for equipments**

The choice of a certain concept is determined by the working style and the integration of the dental unit within the space of the dental office. The degree of specialization of the dentist's aid can influence in turn this choice.

From this point of view, two tendencies can be distinguished: the operational solo-work or the solo-duo work is developed in the European space, especially in countries of Latin origin, implying a lower degree of specialization of the dental assistant, this one taking over occasionally certain functions during the therapeutic procedures. But in America and in the European Anglo-Saxon space, completely assisted working styles are required, which developed the "four hands work" concept, with the dental assistant/hygienist participating actively in the procedures, according to her/his high degree of specialization and training in the ergonomic work. The dental assistant has precise attributions in the procedures carried out in a precise succession, established previously. Thus, if the prerequisites of choosing and adapting most favorably the equipment and instruments are fulfilled, the results are the maximal efficacy as greater of the work and a minimal effort.<sup>4</sup>

Currently, there is a major preference for the ISO 1 concept, which is currently used by 89% of the German dentists, 9% of the preferences being oriented towards ISO 3 (Prof. Engles, Tübingen, 2004). This is the major kind of equipment commercialized by the producers. The study remarks the fact that the faculties of dental medicine use also this model, which underlines the importance of educating the students about the criteria of the dental ergonomics. A future educational approach will be oriented towards the detailed characterization of the 4 types of units, in

order to facilitate a future choice with full ergonomic knowledge, in accordance with the four ISO concepts. The application of the criteria of dental ergonomics can generate a series of directions at the operational level in the dental office that are able to guide the dentist.

When working with the MOD in the dental specialties where it is most frequently used, it is important to know that the concepts ISO 2 and ISO 4 allow more space for positioning the operating microscope. Unfortunately, there are evidences that these 2 concepts are used only in proportion of 2%. This can be due to the fact that dentists are in general not familiar with working in the "12 o'clock position" and in "four-hands" style, while the ISO 2 and ISO 4 - type of dental units favor especially this working style.

### **ACTIVITY STRUCTURING AND WORK ANALYSIS IN THE DENTAL OFFICE FROM THE ERGONOMIC POINT OF VIEW**

Two aspects - physical and cognitive, characterize the design of the user/technology interfaces (the man/machine interface). For instance, the physical sizes of the equipment must correspond to the anthropometrical size of the user(s).

When designing dental equipment, the following physical criteria should be taken into account:<sup>17</sup>

- The dental equipment should correspond to a variety of patients as greater as possible;
- The interval of height adjustment should be large;
- The dental equipment should allow a convenient placement of other equipments; these must be easily accessible during the patient's examination at a certain height;
- The color, form, texture of the instruments, the direction of movement and the force necessary to operate are chosen within the limits of the human capacities.

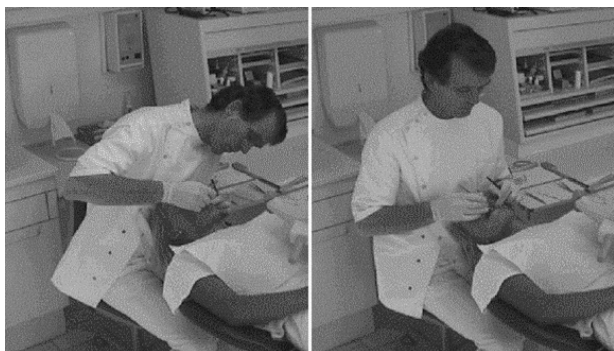
The cognitive design refers to:

- The disposition of the commands on the control panel of the dental unit in a logical manner;
- Understandable instructions to use the equipment.

The working place design and the space division affect the operator's health and the quality of his/her work. The ergonomic principles in organizing the space are as follows:<sup>8</sup>

- The comfort (the most frequently used equipments are in the most convenient place for the operator).

- The positioning (sitting for access to the patient without deviations the posture, such as bending, inclining, rotation etc.). (Fig. 3)



**Figure 3.** Non-balanced posture (left) and correct position of the clinician (right)<sup>6</sup>.

- The frequency (the most frequent operations/procedures carried out simultaneously are placed as nearer as possible).

As a consequence, the operator maintains the best working position and invests a minimal effort, and reduces the physical and psychical effort.

Physical conditions of environment: they include aspects such as the light, the thermal comfort, the noise, the air quality in the dental office (the microbial load etc.), the vibrations and the electromagnetic fields.

The design of the activity, the selection and specialization: the organization of the activity has to include breaks and working in shifts to avoid oversolicitation. The personnel selection is done on the basis of specific skills and qualities: physical, cognitive and social.

The organizational design and management: involves the team analysis of the working style, so that the activity can be optimized, the costs reduced and the new technologies implemented and integrated as advantageously as possible.

The application of the ergonomic criteria in the dental practice can be done in individualized manner, opting for a certain arrangement in his/her consulting room or for a certain concept on basis of the ISO concept chosen, together with the rational organization of the whole activity. The essential elements that guide the activity are:<sup>10</sup>

- A correct posture of work;
- A correct position of the patient;
- Visualizing techniques according to the case;
- A division of the working space in accordance with the human physical capacities;
- An efficient handling and organizing the instruments, thus permitting major economies of time and movements, and an efficient work in teams.

The appropriate correct working posture should be borne in mind as the starting point of all the other determinants. The patient's position is established and the equipments and instruments are organized according to this and to the correct posture during the activity.

Dentistry of the XXI century tends to give a greater importance to the human factor, neglected frequently before in favor of the technological factor. The transition from the ergonomics centered on technology to the human-centered ergonomics is also now the major preoccupation of the industry, which eventually has decided to optimize the quality of the activity in parallel with the reduction of the risks which generate conditions specific to the occupation. Unlike the initiatives in the past, the human-centered ergonomics gives priority firstly to the patient, secondarily to the practitioner and thirdly to the working place design.<sup>6</sup>

The design of the working environment, that has to be adapted both for the patient and for the practitioner's requirements, can be conceived only after establishing a correct relationship between the operator and the patient. A relatively new concept, called "performance logic" was introduced in the dental practice and in dental education.<sup>5</sup> According to this concept, the essential components of the ergonomic conditions are the patient's and dentist's positions. The decision on of these comfortable and physiological positions as well as the optimal arrangement of the working environment is the result of a proprioceptive feedback, by which the individual adjusts its activity responding to the signs sent by the internal receptors. In 1987, the World Health Organization, referring to this concept, quotes out of a report of experts: "The logic of the efficiency is an approach that can be considered as an indicator of the future".

The ergonomics offers to the physician, to the other members of the dental team the possibility to carry out a potential performance without putting at risk the own health and physical condition, and the possibility to provide optimal cares to the patients.

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