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ERGONOMIC DESIGN PROPERTIES OF DENTISTRY EQUIPMENT

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Abstract: *Dental workers are at high risk in relation to specific musculoskeletal disorders,which can lead to the appearance of occupational diseasesthat refer to the dysfunction of the neck, back, arms, handsand fingers. According to the data from the literature, it is estimated that as a result of the working conditions the musculoskeletal injuries occur in 54% to 93% of dental professionals. This paper discusses the functional systems for dentists in terms of ergonomic designing, selection and adjustment of the equipment that is used in dentistry. Special attention is devoted to the analysis of chairs for patients and dentists, including the possibilities for their ergonomic improvements.*
Keywords: *ergonomics, dental equipment, muscosceletal disorders*

INTRODUCTION

Dentists and dental technicians are at high risk in relation tospecific musculoskeletal disorders. These disorders can lead to the pain and dysfunction of the neck, back, arms, hands and fingers.

The main risk factors among dentists could be classified as biomechanical and psychological. Important risk factors are longlasting static postures and forced positions (especially important for the region of neck, arms and shoulders), the repetition of movements and the need for the application of sustained physical strength (usually related to the arms and hands), inadequate lighting (intensity and positioning), inadequate design of instruments, biological and chemical exposures, and stress.

The goal of this research is to give the brief outline of the man-machine system for dentists, from the aspect of identification and analysis of functions of dental equipment, that should meet the ergonomic criteria for optimal work.

THE ERGONOMIC CRITERIA FOR ASSESSMENT OF DENTIST'S WORKING ENVIRONMENT

One of the approach for the assessment of design of products is based on the application of ergonomic standards and reccommendations [1]. They should provide an important requirement relating to the man-machine system, which refers to the fact that product with its design does not induce an error[2] during the work.

In connection with the design of dental equipment,it is important to consider the following standards and directives[3-7]:

- ISO/TC 106/SC 6 N 411, Ergonomic requirements for dental equipment
- ISO Standard 11226 “Ergonomics – Evaluation of static working postures”.
- ISO Standard 6385 “Ergonomic principles in the design of work systems”.
- Directive concerning Medical Devices. European Medical Device Directive (MDD), 12 July 1993, 93/42/EEC.
- Directive concerning health and safety at work, 89/391/EEC.

In the connection with the goal of the research, it wasnecessary to explore the modern constructive achievements and technical solutions concerning the dental equipment, their influence on dental workers, and their compliance with the specified ISO standards and directives.However, in this paper, particular attention has been directed to the elements that probably have the greatest ergonomic impact on the dentists - the working chairs and the chairs for patients.

WORKING CHAIRS FOR DENTISTS

When it comes to the working chair, it must provide the minimum angle between the thigh and lower leg of at least 110°[3]. This angle is necessary for the

correct position of the pelvis and spinal column and stimulates active anatomical upright body position. The result is a least burdensome position. This approach allows the movement of the chair in the sitting position as well as more space above the thigh, for the positioning of the patient.Figure 1 illustrates the new generation of functional, ergonomic chair for dentists.

Figure 1. Dentist chair with adjustable armrests(http://www.posiflexdesign.com).

The seat should be height-adjustable, and the front edge should be shot down and away from the legs so as not to impede circulation and innervation to the legs of practitioners.
Support for hands is essential for health and comfort. Contemporary chairs provide support for the hands and allow a wide range of movements. The armrests should be placed below level of the elbow so that shoulders are not raised when restraints are used. They must not impede access to the patient. But some studies have revealed that the use of armrest reduces work of the upper muscles, as well as the frequency and volume of the arm during the performance of regular dental procedures.

DENTAL CHAIRS FOR PATIENTS

The basic principle is that the patient must lie comfortably without feeling pressure on the back. The chair should have a flat surface in order to achieve relaxed position of the patient.
The chair should enable the three movements of the head of the patient:
- Frontal in the occlusal plane of the mandible from 0° (horizontal), when the dentist sits next to the patient, to about 45°, when the dentist is sitting behind the patient's head, and back in the occlusal plane of the maxilla of 20°-25° behind the vertical plane for treatment the maxilla [3];
- Lateroflexio (turning heads obliquely to the side), about 30° [3], right and left. This movement always follows the movement of the upper body of the patient in the same direction to head and body were in a straight line. Consequently, the patient is uncomfortable to turn his head obliquely to the side, especially at a greater angle and for longer periods. Therefore, it is essential that the patient's body follow the position of the head positioning the head restraint so that the body is in a straight line;
- Around the longitudinal axis, a maximum of about 45 °, right and left [3].
For decades, the focus of many manufacturers of dental chairs was the comfort of the patient. However, when compared to the average time that a patient spends in the chair with the time the dentist spends in the work, it becomes obvious who is at greater risk of developing discomfort, disorder and disease development.
As a result of consideration of the problem of the pain in relation to the work and injuries among dentists, manufacturers are increasingly focusing on ergonomics of chairs for a patient from a position of dentists. Desirable characteristics should facilitate the neutral position of the spine, shoulders, elbows and joints of the hand. On the one hand, the chair should allow close positioning of the dentist over the mouth of the patient. On the other hand, it is necessary to ensure the correct position of the spinal column, leg and arm of dentists in order to minimize the stress and fatigue.
For designing purposes, the following elements of the chair should be taken into account:
Small and thin headrests
This allows for more legroom and easier access to the patient. At the same time, allows greater flexibility for positioning the patient. Double mobility allows rotation of the inclination of the patient's head.
Narrow backrest
This feature provides additional space for approaching the dentist and maneuvering.
Flexibility
The individual parts should be adjustable in terms of placement of patients of different sizes and ages.
Armrests
These parts should be positioned so as not to interfere with access to the patient, and not to touch the knees of a dentist and thus put a pressure in a static position, which can be long standing.
Height adjustment
The chair should be adjustable in height enough for the dentist to work. Otherwise, the dentist is forced to hold hands raised, which affects primarily on the fatigue of the shoulder area and other parts of the muscles involved in the process.
Handpiece holders
There are several technical solutions forpositioning of this system. Each of them has its advantages and disadvantages and can greatly affect musculoskeletal health and productivity of the operator. Of great importance is their primary purpose in terms of activities to be performed: if it comes to interventions in the field of conservative, protective or oral surgery.

AN EXAMPLE OF CONTEMPORARY DESIGN OF A DENTAL UNIT

Figure 2. Contemporary dental unit (www.kavo.com).

Functional parts of the system shown in Figure 2. are:

1. Completely operating concept for quick and direct access to all important functions for time-saving and smooth treatment processes
2. Intraoral camera to enhance dentist excetuion of working tasks
3. High resolution screen with enhanced visibility
4. System software, which supports useful functions and other access to thr relevant patient data
5.Automatic cleaning and a disinfectionhygiene centre of improved usability
6.High performance operating module
7. Modern futuristic design with adequate soothing colors
8. Patient armrest
9.Ergonomically designed patient chair.

DISCUSSION

It is estimated that as a result of the working conditions,the musculoskeletal injuries occur in 54% to 93% of dental professionals, and most injuries occur in the spine (neck and back), shoulders, knees and hands [8].

While special procedures increase the risk of injuriesto the fingers and hands, bad posture is a risk factor in all procedures. This is connected with the requirement that a dentist remains in one position during lengthy procedures. These problems are compounded by the stress and time demands.Musculoskeletal disorders (29.5%) and cardiovascular disease (21.2%) are the most common reasons that lead to damage or even permanent disability among dentists [9].

Good ergonomics is essential, so the ability to work, efficiency, and high performance can be maintained at a high level during working life. The importance of application of ergonomics in dentistry is at the high level and includes characteristics and condition of the equipment, such aslighting, noise, etc. Dental chair for patients and doctors, operating units, light sources, handheld instruments and peripheral equipment must be flexible, so as to guarantee good working positions.

One major challenge is the development of ergonomic equipment starting from the functional principles, and keeping the idea of aesthetic design and custom color.On the basis of the aboveconsiderations, taking into the account the surveys that were conducted with dentists, it is possible to define a five coherent priorities in order to improve the ergonomic working conditions of the dentist:

1. improving of chairs for doctors and patients;
2. optimal illumination of the oral cavity of the patient;
3. adequate support for the head, neck and shoulders of the patient and the dentist;
4. using of intraoral cameras in order to increase the field of vision;
5. mechatronic support for shoulders, arms and hands of a dentist.

CONCLUSION

Number of employees in the manufacturing industry and the supply of dental equipment is estimated between 40.000 and 60.000, and the estimation of the number of dentists is between 700.000 and 800.000 worldwide [10]. In particular, problems that are here considered have the implications for a large number of people. In order to get an even better picture of the magnitude of the problem, to this issue should be added also the number of patients - literally every one of us.

MSDshave significant social and economic consequences, including the abandonment of the profession or a significant reduction in working hours. The literature on this subject includes a number of studies, but it is still necessary to analyze the evidence linking risk factors and to work on finding and establishing of the effective prevention. In this sense, the basic recommendations are:

-Formulate the strategy for prevention through the promotion of training in all aspects of ergonomic practices (for example biomechanics) and to reduce the stress.

- Promote educational programs in the field of dental ergonomics for dentists including periodical checking of appearance and status of professional disease.
- Formulation of global guidelines for the design and development of ergonomic dental equipment.
- Promoting the development of standards in all areas of dentistry products.

Of great importance is the cooperation of engineers with healthcare professionals and equipmentusers, as well as with the experts in the field ofergonomics,biomechanics, mechatronics, manufacturing industries, etc., to produce dentistry products that will prevent or minimize the occurrence of MSD.

A significant factor is also the promotion of technological innovations and their integration in the dental practice, as a measure of the highest importance for the improvement of working conditions of dentists.

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