Recognition of musculoskeletal disorders in Tunisian dentists due to dental ergonomics.

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Abstract

The current study is aimed to prove the medico-legal accountability of musculoskeletal disorders developed by dentists due to gestures repeated during their professional lives. An ergonomic study was conducted on a public health dentist's workplace over a time representative of the work period. An over-time activity-measuring software (ACTOGRAM KRONOS) was first used, then a semi-quantitative analysis software for the musculoskeletal disorders of the upper limbs (ERGOROM) was applied to prove the existence of a physical workload on the upper limbs and allow the recognition of these disorders as occupational diseases. Ergonomic recommendations as to the correct layout of the dental office and the gestures to adopt in order to prevent Musculo-skeletal Disorders were made.

Keywords: Musculoskeletal disorders, dentists, dental ergonomics.

1-Introduction

Musculo-skeletal Disorders (MSDs) have raised many questions, including controversial ones, because of their economic and social impact. In Tunisia, a recent study has shown that the direct cost of hospital-based MSDs amounted to € 39,000 for Monastir University Hospital from January 2010 to June 2010 (Bourgeois et al, 2000).

In the literature, MSDs in dental environment represent a real health problem (Jellad et al, 2011; Sluitek et al, 2001; Smith et al, 2006; Graham, 2002).

Indeed, MSD-related research has currently recognized that musculoskeletal disorders in the field of dentistry cause significant absenteeism, a considerable drop in productivity and can in extreme cases result in early departures from the profession (Lindfors, 2006; Leggat, 2007). In terms of recognition, since its last revision in 2007, the Tunisian table of occupational diseases has raised an urgent need for changes

regarding MSDs in occupational diseases in certain sectors, including dentistry.

According to the Tunisian table of occupational diseases, recognizing MSDs at the level of the upper limb requires the victim's exposure to repetitive gestures in a well-defined rhythm and varies according to the type of pathology. For example, for carpal tunnel syndrome, this repetitiveness must be greater than or equal to 10 movements per minute for a cumulative period of time greater than or equal to one hour per working day. This condition seems to hinder the treatment of these pathologies in some non-industrial sectors where the pace of gestures is sometimes difficult to determine, as the working process or the machine does not impose this. This is the case in a hospital environment, especially among dentists.

Several requests for the recognition of MSDs as occupational diseases issued from Public Health dentists working in the Stomatology Department of Fattouma Bourguiba University Hospital were sent to the Department of Occupational Medicine and Occupational Pathology. Their request to the Central Medical Commission to the Prime Ministry has never been followed up. Therefore, we decided to carry out an ergonomic study of the risk factors of upper limb MSDs in Public Health Dentists at the University Hospital hoping to provide objective evidence regarding the accountability of their MSDs in the practice of their profession.

2- Methods

Since its opening in the 70's, the Stomatology Department of Monastir University Hospital has gradually formed a team of five dentists in public health, the most senior one started in 1980. The Department currently has five nurses, a supervisor, four Public Health doctors, two University Hospital dentists and 7 Interns. Consultations take place in the morning for public health dentists and in the afternoons for Interns and University Hospital dentists. Public Health dentists receive on average 7228 patients a year in the Stomatology Department.

The dentist workplace includes the patient's chair, the dentist's chair and a table for the equipment. The equipment layout is illustrated in the plate 1. A dental hygienist assisting the dentist is in charge of two chairs at the same time. This Ergonomic study interested the dentist claiming the declaration of an occupational disease. It was performed after the informal consent of the participant as stated by the ethical committee recommendations. Our methodology was based on a two-step observation method.

A first step of paper-and-pencil observation: This is an analysis stage based on the observation of the dentist in the workplace by defining a statement of observation sheet and a description protocol. It allows the division of the dental acts into basic tasks in order to define a hierarchical organization of the categories of basic tasks according to the type of requirement. It provided a detailed description of the dentist's workplace to allow the identification of the different requirements.

Subsequently, the analysis is done using Actogram Kronos ™ which software used for the chronological work analysis is meaning the individualization of tasks according to their nature and duration. It is performed over a day of real work observations. It is not intended to direct the second analysis step towards the type of job requirement and the type of risk rather quantify the risk (Puriene, 2007).

At the end of this phase, we carried out a chronological analysis of the basic work tasks according to the physical requirements; (postures, movements of the upper limbs, movements, load handling, vibrations), mental requirements (autonomy, pace of work, contradictory or conflicting orders, relationships with colleagues and hierarchy); and requirements related to the general working environment (contact with the public, availability of equipment, additional tasks, interrupting one task to do another). The second step was a semi-quantitative analysis, in fact, several semi-quantitative evaluation methods are reported in the literature (Malchaire, 2004; Karhu, 1977; Keyserling, 1986; Malchaire and Indesteege, 2007).

Our study was based on a video recording over a period representative of the whole morning's work. The analysis of the workplace was based on ERGOROM, which is a software program that is part of the risk prevention strategy SOBANE (Fransson-Hall, 1995; Nakajima, 2007). It consists of cutting the video sequences in 100 pauses and then coding the joint positions for possible analysis.

3- Results

3-1- Chronological analysis of the work activity

The observation of dentists at work for a representative period made it possible to identify the different basic acts of work by chronological analysis of the acts of work as well as the different types of constraints:

The chronological analysis of work acts according to individualized basic tasks showed that 21.7% of the dentists' working time was spent on selecting the equipment or bringing it closer.

The dichotomization of basic acts according to their nature showed that 43% of the dentist's working time was spent preparing, sorting and bringing his equipment closer. The medical act of dentistry in itself represented one quarter (25.2%) of the working hours. Finally, general medical procedures accounted for 20% of the working time (TableI).

The combination of the different requirements observed allowed individualizing three types of mental requirements and seven types of physical requirements. The latters accounted for 51% of the working time.

Steps	Basic task	% of working time	Total
Preparartion	Physician's preparation	2.3	**43%**
	Hand washing	8.7	
	Sorting standing equipment	2.5	
	Management and choice of equipment	**21.7**	
	Preparation of the turbine	3.9	
	Adjustment of the light source	3.2	
	Dentist's preparation	0.7	
GENERAL MEDICAL ACTS	Prescriptions	7.6	20.2%
	Explaining the act	0.4	
	Explaining the treatment	9.2	
	X-ray reading	2.5	
	Equipment request	0.5	
MEDICAL ACTS IN DENTISTRY	Preparation of an anti-septic and an analgesic	3.2	25.2%
	Preparation of the canal with canalary instruments	3.2	
	Preparation of the cavity by the turbine	6	
	Irrigation	2.9	
	Drawing of the turbine hose	2.2	
	Periapical anesthesia	2	
	Drying with cotton	1.4	
	Removal of the dental root	1.3	
	Changing the wick	1	
	Choice and handling of cotton pellets	0.7	
	Gauze packing of the extraction site	0.7	
	Putting back the turbine hose in place	0.6	
REST	Rest to allow the patient to spit	7.3	7.3%
MOVEMENT	Moving between the examination room and the prescription office	4.3	4.3%

Table I: Basic task breakdown according to work steps.

3-2- Semi-quantitative analysis of MSD risk factors:

3-2-1- The neck:

The study of the neck mobility over a representative working time in the transverse and sagittal planes showed that the neck was in flexion of more than 40 degrees or in extension in 77% of the working time with a low variability of movement (31.3%).

The lateral flexion was visible in 40% of the working time and the right or left rotation in 63% of the working time with a high repetitiveness (40.4%). (Table II)

Neck %	
Flexion / Extension	
in neutral (0 to 40 ° flexion):	23.0
in open flexion (> 40 °) or extension:	77.0
Variability :	**31.3**
Lateral bending	
in neutral (<10 °):	60.0
in visible lateral flexion (left or right)	40.0
Variability :	34.3
Rotation	
in neutral (<10 °):	37.0
in visible rotation (left or right):	63.0
Variability :	40.4

Table II: Quantification of risk factors for MSDs of the neck

3-2-2- The shoulder:

The study of shoulder movements over the working period showed shoulder flexion or abduction movements of 20 to 60 degrees in 53% of the working time, and a shoulder flexion or abduction > 60 degrees in 25% of the working time with a significant variability of movements of 53.5% reflecting the repetitiveness of shoulder flexion and abduction.

In addition, the video recording showed that the shoulders were in adduction, extension or visible rotation in 80% of the working time with a low variability (25.3%) demonstrating an isometric position. (Table III)

Shoulder	%
Flexion or Abduction	
in neutral (0 to 20 °):	22.0
in flexion or abduction from 20 to 60 °:	53.0
in flexion or abduction greater than 60 °:	25.0
variability :	**53.5**
Adduction , Extension or Rotation	
in neutral:	20.0
in adduction, extension or visible rotation:	80.0
Variability **:**	**25.3**

Table III- Quantification of Risk Factors for Shoulder MSDs**.**

3-2-3- The elbow:

The analysis of the elbow movements over a studied representative working period showed a more than 60-degree flexion of the elbow in 84% of the working time, 31% of which was in more than 100-degree flexion. The variability of movements was high and close to 55.6%. Furthermore, the elbows were in extreme pronation in 70% of the working time with low pronation / supination variability (30.3%) (Table IV).

Elbow	%
Flexion / Extension	
in bending from 0 to 60 °:	16.0
in flexion from 60 to 100 °:	53.0
in bending greater than 100 °:	31.0
Variability:	**55.6**
Pronation / supination	
in neutral:	27.0
supination :	3.0
in extreme pronation:	70.0
Variability **:**	**30.3**

Table IV- Quantition of risk factors for elbow MSDs

3-2-4- The wrist :

The semi-quantitative analysis by video recording confirmed the considerable biomechanical constraints that dentists undergo at the level of the wrists with a great gestural variability. Indeed, the pressure was exerted either toward the flexion / extension (51.5%) or at the level of the cubito-radial deviation (55.6%) proving the repetitiveness of the gestures at the level of the wrist.

In addition, the wrist load study showed that dentists spent 85% of their working time with the wrist in a cubito-radial deflection and 75% of that same time with the wrist in more than thirty-degree extension or flexion.

In another register, the digital isometric measurement of dental instruments was spread over 79 % of the working hours. (Table V)

Flexion / Extension	%
in neutral from -30 to + 30 °:	25.0
in extension greater than 30 °:	33.0
in flexion greater than 30 °:	42.0
Variability:	**51.5**
Deviations	
in neutral:	15.0
in visible cubital deviation:	44.0
in visible radial deviation:	41.0
Variability	**55.6**

Grip	
No grip	6.0
Finger grip with a few fingers:	79.0
Total grip with all the hand:	3.0
Pressure (fingers or hand) or	3.0
***hammer* Hypothenar:**	
Variability:	32.3

Table V: Quantification of risk factors for wrist and hand MSDs

4- Discussion

The open-observation chronological analysis of the activities made it possible to highlight some realities and to confront the physical constraints with certain evidence. Indeed, our study showed that 43% of the dentist is working time was spent preparing for the dental ac with 21.7% bringing the equipment closer, which is synonymous to an obvious anomaly in the architectural and organizational aspects of the workplace.

The dental sector is subject to a dual constraint in terms of layout and space. In fact, to prevent aerosols generated during treatment from being deposited on other equipment and products and to prevent the spread of infections, all equipment should be "hidden". There should be as few items as possible on the counters. Everything is "hidden" in drawers, so dentists are always leaning to access it. Moreover, in dentistry, many products are used and it often happens that at the beginning of treatment, dentists do not know in advance all the products that they would need and have therefore, to look for them during the act. "Back delivery" of equipments is also another source of shoulder discomfort for dentists (Gilles, 2007).

Rearranging the workplace using more easily removable storage furniture may decrease the amount of time required to bring the equipment closer together during this preparation task. On the other hand, assigning a dental hygienist the task of exclusively preparing the equipment and instruments at each dentist's chair in the Department will certainly reduce the preparation time for the dentist.

Regarding the time spent hand-washing, estimated at about one-tenth of the total working time, the use of antiseptics would shorten the time spent on this task. In addition, the analysis of activities according to the type of requirement showed that both physical and mental requirements occupied equal working time. A Brazilian cross-sectional study of 13,602 employees in all sectors showed that the prevalence of MSDs was 49.9% and that these were correlated with dentistry and dental hygienist occupations, as well as with high physical demands and mental constraints of the job (~~Rose~~ Barbosa, 2012).

In the current study, the semi-quantitative analysis of MSD risk factors showed that the neck is in a static position in the sagittal plane while the lateral rotation and flexion were repetitive. These positions could result in MSD of the neck. A Polish study carried out in 2011 on 220 Polish dentists showed that 92 of them had MSDs with the neck being affected in 47% of the cases (Rucker et al, 2007).

With regard to the shoulders, the period of work studied showed the existence of repetitive movements of shoulder flexion or abduction on the small amplitudes over more than half of the working time and repetitive movements of shoulder flexion or abduction on the strong amplitudes on a quarter of the working time. This shoulder mechanics is known to create tendinopathies of the rotator cuff.

Moreover, the video recording allowed us to note the position of the shoulders in adduction, extension or visible rotation in 80% of the working time with a low variability (25.3%) proving an isometri position. This is the isometric contraction of the shoulder. Here again, it is a question of recognizing the tendinopathy of the rotator cuff as a professional disease and including it in the Tunisian table of occupational diseases.

As for the elbow, the analysis of its movements over a studied representative working period showed a more than 60-degree flexion in 84% of the working time with a 55.6% variability of the movements testifying a significant repetitiveness. In addition, the extreme pronation of the elbows in isometry was noted in 70% of the dentist's working time.

The extreme strain exerted on the wrists was highlighted by the video recording semi-quantitative analysis and it confirmed the impact of the biomechanical constraints on the wrists and the very great gestural variability at their level. Indeed, the strain was exerted either towards the flexion / extension (51.5%) or at the level of the cubito-radial deviation (55.6%) proving the repetitiveness of the gestures at the level of the wrist in both the sagittal and frontal axes. Moreover, the study of the stress exerted on the wrist showed that dentists spent 85% of their working time with the wrist in cubito-radial deflection and 75% of this same with the wrist in more than thirty-degree extension or flexion.

Finally, the digital isometric measurement of dental instruments was spread out over 79% of the working hours, explaining the continuous tightness of the tendons of the fingers and therefore the risk of tendinitis of the inter-phalangeals. This finger grip is all the more painful as it requires a relatively great strength especially during tooth descaling.

5- Ergonomics approaches:

5-1- How to reduce shoulders, neck, upper and lower back MSDs?

Changing the dentist's postural habits and movements that have become automatic over the years is difficult because when attention is centered on the task, efforts to stay focused on posture usually do not last long. It is therefore better to review the layout or the configuration of the workplace to promote a better work posture. Work postures are the result of several work components including methods that influence the position of the arms, neck and lower back as well as the type of equipment used and the eye-to-task distance. (Figure I, plate 1)

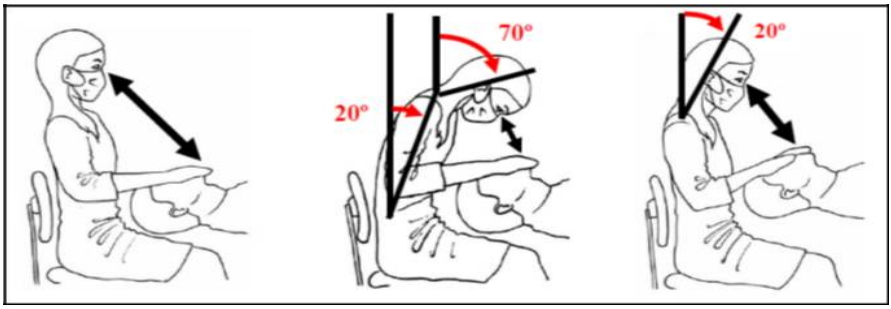

Figure I: Ideal theoretical position / very weak neck / almost-normal neck position.

The characteristics recommended for a good chair are:

- A height-adjustable lumbar support that moves forward enough to support the lower back while working
- Adjustable seat height
- Adjustable angle seat The ability to move easily on its five wheels.
- Separately adjustable angle of the seat and lumbar support
- The seat should end 5 cm (2 inches.) behind the user's knee.

Two types of chairs can be considered: with or without elbow support. The armrests allow a relief of the mobilizing muscles of the shoulders (trapezius, deltoids, rhomboids, etc.). Several types of arm supports are available such as those telescopic swiveling supports used to maintain forearm mobility. Dentists use these as elbow support with cushioning to ensure comfort. (Photo I)

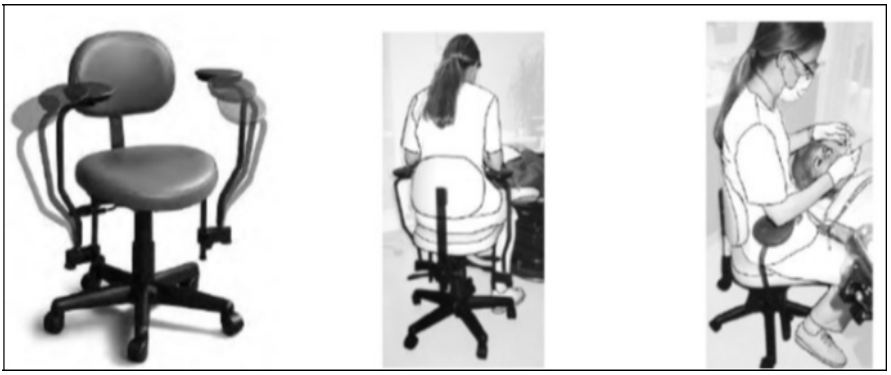

Plate I: Elbow Support with Pads.

The use of this type of chairs has resulted in a significant reduction in the muscular load of the upper trapezius. However, the armrests of standard chairs are not suitable for dental workers whose arms must move forward to reach the different quadrants.

In addition, the position of the dentist at work is very important to consider in the MSD prevention approach. The ideal theoretical position for the back would be the upright position, yet the eye-to-task distance would be too great because the patient is positioned low.

When getting closer to the patient, the dentist reduces the eye-to-task distance. This distance becomes certainly very short but makes the dentist incline the neck at least seventy degrees when the patient is positioned low. By raising the height of the patient's head, the eye-to-task distance becomes shorter and the inclination of the neck does not exceed twenty degrees (Gilles, 2007). This is why the American Health Association is currently recommending the use of dental beds rather than articulated back chairs.

Furthermore, other ergonomic recommendations can help prevent the occurrence of MSDs in dentists and these include:

- The use of indirect vision with mirrors for areas that are difficult to see.

Plate II : The angulation of the wrist is decreased when the suction device is given to the patient

- The use of telescope glasses during dental acts. Indeed, some case-control studies have shown a marked improvement in posture among dental students when using magnifying glasses, especially when they are worn very early at the beginning of university studies (Maillet et al , 2008)

- The introduction of mini-breaks and breaks.

- Work scheduling: divide the long treatments into several sessions.

- Doing some exercise to restore muscle balance: A literature review showed that several types of exercise have been recommended, but in the end, they do not all have the same impact on prevention. (Hoe at al; 2012 ; Norashikin et al, 2011)

- The adoption of certain recovery positions during sleep.

5-2- How to reduce elbow, wrist and hands MSD

The first recommendation aims at decreasing the postures that involve a deviation of the wrists. This implies trying to keep the wrists

in a neutral position by giving the suction device to the patient, which frees the left hand and decreases the angulation of the left wrist (ulnar deflection, flexion and extension).

It is also necessary to use suction with clip controls rather than round knobs and to prevent the tubing from pulling on the instruments (Photo II).

It is also recommended the thumb clamp work should be reduced by modifying the mirror grip in case of pain (holding it between the index and middle fingers), introducing mini-breaks and work scheduling.

Physical therapists advise dentists to conduct some muscle warming of the fingers that promote the spread of synovial fluid before

starting the acts. Some preventive measures include the use of larger diameter pens in order to reduce the grip efforts as well as the modification of the pen grip in case of pain due to writing.

6-Conclusion

The postures adopted during the dental work are related to the configuration of the dental workplace, the equipment and the movement patterns developed by the dentist. The present work is aimed at performing an ergonomic study of the workplace of the public health dentist who is subject to several MSDs of the upper limb in order to facilitate the recognition of any occupational disease and carry out a good ergonomic layout of the dentists' workplace at the University Hospital.

The MSDs objectified by the present ergonomic study may in the long-term result in several disabilities. The Tunisian Table of Occupational Disease Compensation No. 82 is still insufficient to guarantee legal compensation for practicing dentists. Indeed, many declarations have been dropped after being examined by the Central Medical Commission to the Prime Ministry.

In the case of this patient, thanks to the semi-quantitative analysis, the central medical committee recognized her rotator cuff syndrome and right carpal tunnel syndrome. The ultimate goal of this work is to try to sensitize lawmakers to reconsider or review the table N ° 82 to ensure the medico-legal rights of the patients in the dental sector and try to reinforce prevention at the level of the design and layout of the dentist's workplace.

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