

Applications of Ergonomics In Dentistry: A Review

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ABSTRACT

Background: Ergonomics is the scientific study of people and their working conditions, especially done in order to improve effectiveness. In Greek, “Ergo” means work, and “Nomos” means natural laws or systems. Ergonomics, therefore, is an applied science concerned with designing products and procedures for maximum efficiency and safety. Ergonomics modifies tools and tasks to meet the needs of people, rather than forcing people to accommodate the task or tool. An ounce of prevention is better than pounds of cure. That’s what dental health care workers spend their day telling their patients, but it also applies to working conditions that can cause pain in the neck, shoulder and hand to a dentist. Dentistry is a profession that generally produces various musculoskeletal pains and soreness which are slow to appear and consequently the symptoms are usually ignored until they become chronic and permanent lesions become evident. This article reviews risk factors causing musculoskeletal disorders, their signs, symptoms, application of ergonomic principles and possible interventions, so that one can be aware of the developing problems so as to change his/her approach to work or alter the workstation set up to prevent further injury.

Keywords: Ergonomics, Musculoskeletal disorders (MSDs), Dentistry, Exercises, Neutral posture, Occupational hazards.

INTRODUCTION

In Greek “Ergo” means work, and “Nomos” means natural laws or systems. Ergonomics, therefore, is an applied science concerned with designing products and procedures for maximum efficiency and safety. Ergonomics modifies tools and tasks to meet the needs of people, rather than forcing people to accommodate the task or tool. The goal of ergonomics is to establish a safe, healthy, comfortable, and efficient working environment, thereby preventing health problems and improving productivity and job satisfaction [1,2]. Ergonomics helps in increasing awareness of the postures used during work, redesigning the workstation to promote neutral positions, examining the impact of instrument use on upper extremity pain, and

following healthy work practices to reduce the stress of dental work on the practitioner’s body [3].

Dentistry is a profession in that its clinical performance is restricted to an area covering only a few tens of millimeters (the mouth), and that it requires repeated and precise force applications. These situations demand a fixed posture that can create occupational hazards in both dentists and dental students. In dental clinics there are very few activities that can cause sudden injuries, rather it is an accumulation of harmless working positions over months and years, that cause irreversible injuries. Dentists and dental students often assume awkward physical positions while providing treatment to get a better view of the intraoral cavity, provide a more comfortable position for the patient, and/or operate

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equipment, and reach for instruments and supplies [4,5].

Musculoskeletal disorders (MSDs) represents more than 60 percent of occupational injuries in the dental field. There has been a rise in MSDs from extended working hours, awkward postures, repetitive movements, prolonged standing/unsupported sitting, poorly designed workstations, improper work habits, and instruments that are difficult to manipulate [6]. The prevalence of general musculoskeletal pain ranges between 64% and 93% with the most frequent injuries occurring in the spine (neck and back), shoulders, elbows, and hands [7]. The frequency of these disorders is also gender related and research supports the higher incidence among female dentists which is nearly double than that of males. Research shows that left-handed dentists especially suffered from neck and shoulder pain when compared with right-handed dentists [8,9,10]. In a study done by Gopinadh et al [11] to study the prevalence of MSDs in dental professionals they concluded that general practitioners were more affected followed by prosthodontists, oral surgeons, endodontists, and periodontists. Rabiei et al (2012) found that endodontists had more experience of pain followed by prosthodontists, oral surgeons, and periodontists [12].

MSDs are disorders and injuries of the musculoskeletal system involving nerves, blood vessels, tendons, ligaments, joints, and muscles. At one end of the spectrum an MSD can be mild and infrequent; at the other end, MSDs can be severe, chronic, and debilitating. Some signs, symptoms, risk factors and off-the job activities contributing to MSDs are outlined below.

- a) Signs of MSDs: - Decreased range of motion; loss of normal sensation; decreased grip strength; loss of normal movement; and loss of coordination.
- b) Symptoms of MSDs:- Excessive fatigue in the shoulders and neck; tingling, burning, or other pain in arms; weak grip, cramping of hands; numbness in fingers and hands; and hypersensitivity in hands and fingers.
- c) Risk Factors for MSDs:- Repetition; forceful exertions; awkward postures; vibration; poorly

designed equipment/workstation; improper work habits; poor fitness level; and lack of rest/recovery.

- d) Off-the-Job Activities:- Home computer use; repetitive activities using the fingers; prolonged/awkward postures at home; use of household tools; and activities involving repeated heavy lifting, bending, twisting, or reaching [13].

Fortunately, good ergonomic practices can drastically reduce the likelihood that an MSD will slow us down. Proper ergonomics in dental setting includes neutral posture positioning, dynamic movement of the body, and the use of as little force as possible [1]. This article reviews the various ergonomic concepts and principles which can be incorporated into the day to day clinical practice so as to reduce MSD and enhance efficiency of the clinician.

Applications of ergonomics in dentistry

Ergonomic improvements in seating, instrumentation, magnification, lighting, gloves, working postures and techniques which ensure proper balance between job requirements and work capabilities have been briefly described in the following paragraphs.

Doctor's stool

The two forward curves of the body counter-balance the two backward curves. These curves allow the entire trunk to remain balanced over the center of gravity. Since the operator is most commonly in a seated position while working, the design and use of the stool becomes a critical part of the balance.

- a) The operator's stool should have a broad base.
- b) The seat should be adjusted so that the operator's knees are slightly below the hip level and thighs are 100° – 110° to the trunk with the feet resting flat on the floor.
- c) The backrest or lumbar support should be adjusted to fit in the center of the operator's lower back where the forward curve of the lower back meets the

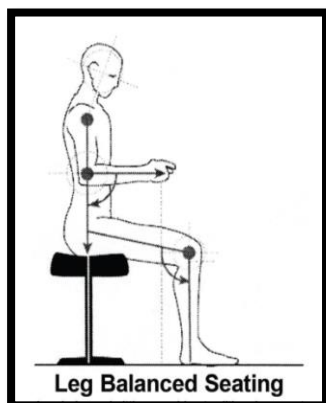


Fig 1: Leg balanced seating.

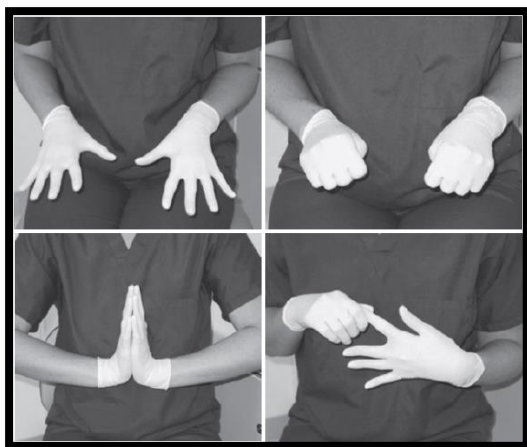


Fig 2: Stretching exercises for wrist and fingers

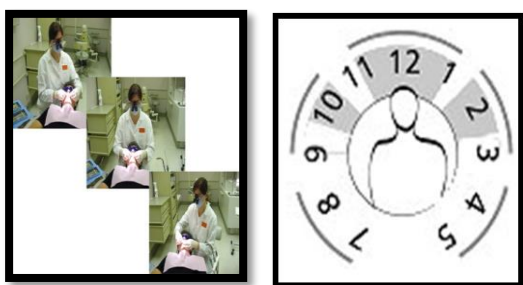


Fig 3: "O" Clock positions.

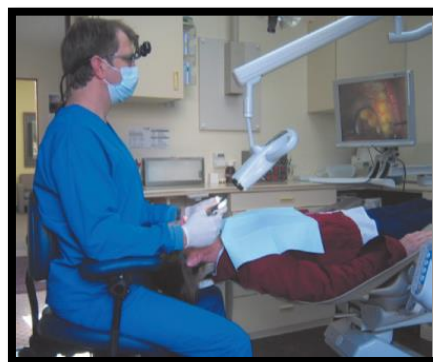


Fig 4: Procedure scope.



Fig 5: Dental microscope.

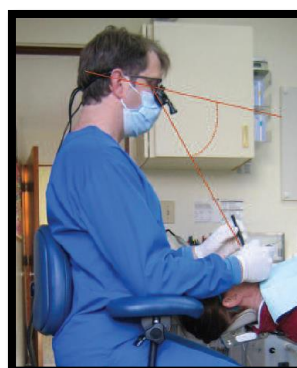


Fig 6: Dental loupes.

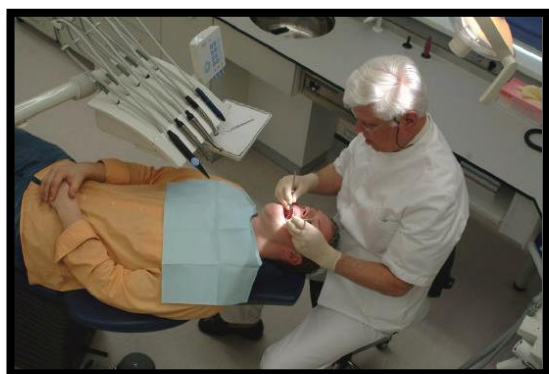
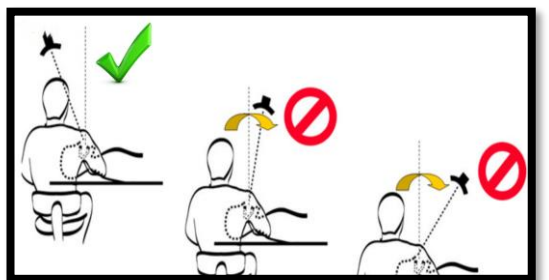


Fig- 7: Proper lighting.

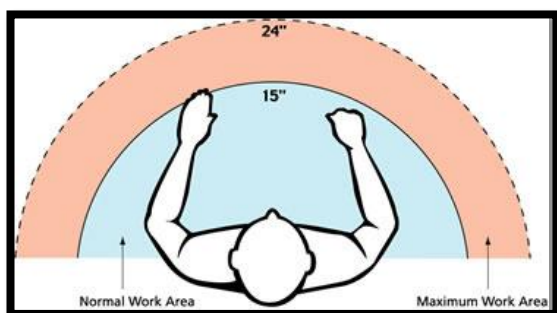


Fig 8: Equipment layout.

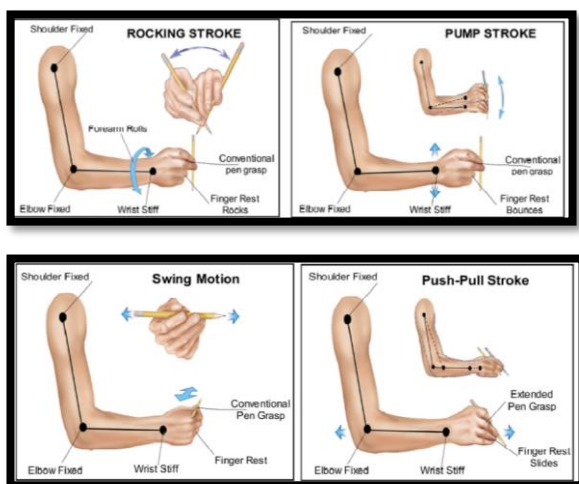


Fig 9: Biocentric Technique.

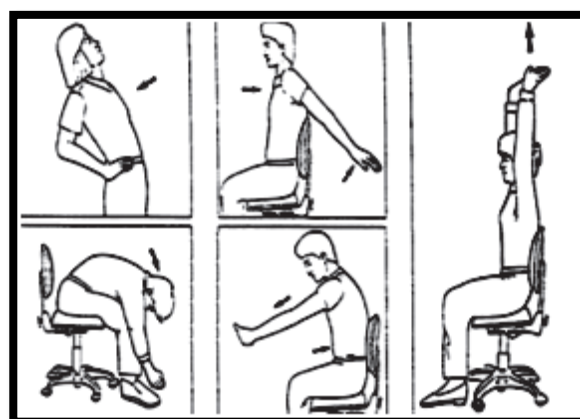
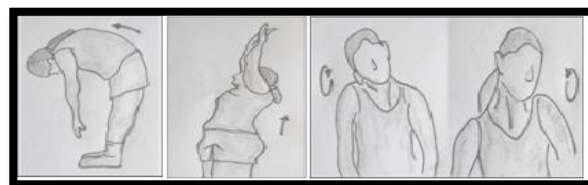
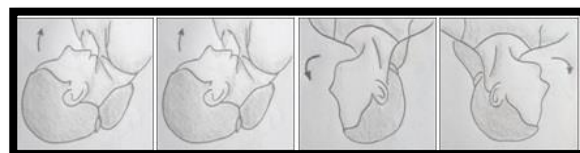


Fig 10: Body stretch exercises.

backward curve of the middle back [14,15,16,17].

Patients chair

- When seating a patient, optimal results will be achieved when their oral cavity is positioned at a height equal to the seated height of the clinician's heart. Positioning the oral cavity above heart level will limit the advantage and increase the rate of shoulder fatigue. On the other hand, positioning the oral cavity below the recommended height will result in non-neutral working postures including over declination of the head, forward and/or lateral bending of the torso [14].
- Ideally the patient should be supine for treating the upper arch and semi-supine for the lower arch (20° from supine position). A contoured neck cushion can be used to achieve proper orientation of the occlusal plane [18,19].

- c) When the patient is properly positioned, operator's shoulders, elbows, and wrists should be in a neutral position such that:
 - i. upper arms are close to the body
 - ii. elbow / forearm angle is close to 90°
 - iii. wrists are in line with the forearm with no more than 20-30° extension. (Fig-1).
- d) The chair should be raised so that the operator's thighs can freely turn beneath the patient's chair [14,15,16,17].

Hands

- a) Maintain neutral position of joint.
- b) Reduce the use of excess force and highly repetitive movements.
- c) Use appropriate rests when doing precision tasks and alternate between extraoral and intraoral rests.
- d) *Avoid excessive finger movements.*
- e) Stretch your wrists and fingers, especially between the thumb and index finger (Fig-2) [1,20].
- f) Wearing ambidextrous latex gloves is analogous to encasing our hand, fingers, and wrist in a giant rubber band. Delicate nerves and blood vessels are affected from being squeezed hour after hour. Our hands are one of our most precious tools, so we should learn to take our gloves seriously and look for the best fit and feel [21].

Working Posture

A neutral working posture is defined as one which supports uncompromised musculoskeletal balance of the clinician. This consists of dynamic positioning where the clinician operates in different locations around the oral cavity rather than static operation. Changing positions not only serves to improve vision and access into the oral cavity but also shifts work to other muscle groups. By using the clinician's stool to navigate around the patient, static and awkward postures can be avoided. Most clinicians attempt to use a wide range of positions

around the patient's head, often referred to as the "o'clock positions" [14,15,16,22] (Fig-3). Movement is imperative in clinical operatory to decrease the structural damage from prolonged static posture [23].

- a) Adjust patient position to minimize twisting or forward bending at the waist.
- b) Alternate work positions and/or work tasks. (For example: alternate between standing and sitting) [23].
- c) Use indirect vision (e.g., mirrors) to eliminate awkward positions [14,15,16].

Magnification

Dentists have been found to adopt a posture that is ergonomically better when using magnification lenses compared to their posture when using regular safety glasses. Forward head posture is common in unmagnified vision and can lead to various muscle imbalances of the neck region [7,24].

The types of magnifications available are:

- a) Procedure scope- Procedure scope allows the clinician to sit upright while viewing the operation site on an LCD screen. The images are taken by an extra-oral camera placed above the patients mouth [24]. (Fig-4)
- b) Dental microscope- Dental microscopes fitted with ergonomic adapter also enables near neutral posture. These provide a magnification of 2× to 20× and use binocular vision, causing minimal eyestrain [24]. (Fig-5) Dental microscopes provide better visualization, better treatment outcomes and better working postures during endodontic treatment [25].
- c) Loupes / telescopes- Dental loupes (or telescopes) are the most frequently used form of magnification. They offer two to five times magnification. With appropriate selection, well-adjusted loupes can enhance posture and position during procedures, resulting in improved ergonomics. Loupes with good declination angle will allow the

operator to work in minimal head forward position [24]. (Fig-6)

Lighting

Light positioning is a critical factor affecting body posture during clinical operation. The goal of proper lighting is to produce even, shadow-free, colour-corrected illumination concentrated on the operating field. For optimal illumination the light-line must be as close to the sight-line as possible. The light source should be in the patient's mid-sagittal plane, directly above and slightly behind the patient's oral cavity and 5° toward the head of the operator in the 12 o'clock position [14,15,16]. (Fig-7) Head-mounted lighting eliminates shadowing, and the light parallels the dentist's line of sight resulting in better ergonomic posture [26].

Instrumentation

The design of dental instrumentation can play a key role in the prevention of negative health effects for its users. Dental clinicians are typically responsible for selecting and maintaining their own instruments and equipments. The following are critical points to be noted.

a) Handle shape and size

- i. Larger handle diameters reduce hand muscle load and pinch force. Larger diameter instrument handles allow the operator to grip the instruments with the pads of the fingers and consequently distribute the strain through a larger group of muscles.
- ii. Alternating tools with different diameter sizes allows the user to reduce the duration of prolonged pinch gripping.
- iii. A round handle compared to a hexagon handle will reduce muscle force and compression.

b) Weight

Lightweight instruments (15 g or less) help reduce the muscle workload and pinch force.

c) Balance / Maneuverability

The instrument should be equally balanced within the hand by using appropriate rests so that the tendency to deviate the wrist is reduced.

d) Sharpness

As a tool becomes dull, additional force is required to perform tasks. As a result, it is important to maintain sharpness of the instruments.

- e) Round, textured/grooves (knurled), or compressible handles are preferred.

- f) Colour-coding may make instrument identification easier.

g) Dental handpiece

When selecting *hand pieces*, look for:

- i. Lightweight, balanced models (cordless preferred)
- ii. Sufficient power
- iii. Built-in light sources
- iv. Angled vs. straight-shank
- v. Pliable, lightweight hoses (extra length adds weight) [14,15,16].
- vi. Carescope -combining the technology of an endoscope, lighted mirror, and an intraoral camera on one handpiece with a 360° swivel [27].
- h) The ergonomic benefits of *rubber dams and cheek retractors* are often overlooked. *These aids may assist the operator in reducing neck and shoulder strain by reducing the need for the assistant or dentist to manually reflect slippery cheek tissue.* The dryfield illuminator (Isolite) offers multiple ergonomic benefits by combining suction, illumination, and rubber dam in one product [27].

Mouth mirror

Mouth mirrors have been referred to as the most important yet under-utilized instruments within dental practice. Good mirrors coupled with proper use can significantly increase one's opportunity to maintain a neutral working posture.

- a) If one is unable to visualize the operating site directly while maintaining a neutral posture, use a mirror to prevent awkward body positioning, specifically of the neck and back.
- b) Intraoral mirrors can also be used to reflect additional light on the operating site even when a direct view is possible.
- c) It is important to remember that a mirror should be held lightly and lowered into the mouth with the handle held no more than 45 degrees from the vertical plane [2,14].

Equipment Layout

Dental equipment should be located in a manner which allows you to maintain a neutral working posture. Frequently used items should be kept within a "comfortable distance" (22–26 inches for most people) and not above shoulder height or below waist height (Fig-8). Instruments should be arranged in field of vision at 30° of mid sagittal plane [14,15,16].

Working Technique

- a) "*Biocentric technique*" Biocentric technique shifts the work load from the small muscles of the hand and forearm to the larger muscle groups of the upper arm and shoulder. The four power strokes unique to this technique include rocking, power, push-pull, and swing strokes. Using this technique allows the clinician to maintain a neutral upper extremity position (shoulder level, upper arm vertical, and forearm horizontal) while still offering options for accommodating patients' anatomical variations (Fig-9).
- b) Alternate easy with difficult cases throughout the day and provide buffer periods that accommodate emergency patients or extra time for difficult procedures or patients.
- c) Develop a patient difficulty rating scale to ensure difficult treatment sessions are not performed consecutively.

- d) Be sure to schedule patient appointments so as to have short breaks in between to walk and stretch [14].

Exercises

Researchers suggest that dental professionals should lean back in their stool at least four times during each treatment session as well as spend three to five minutes stretching for every patient seen throughout the day (Fig-10).

- a) Stretching should be gentle and gradual.
- b) Do not stretch a muscle to the point of pain.
- c) Stretches can be held up to 10 seconds and repeated 3-5 times.
- d) Breathe normally while stretching.
- e) If you suffer from a musculoskeletal condition consult a physician before attempting new exercises which you are unfamiliar with.
- f) To relieve eyestrain caused by focusing intensely at one depth of vision for long periods, look up from the task and focus eyes at a distance for approximately 20 seconds [28].
- g) Yoga poses can help to achieve toned neck and back muscles, making them less susceptible to injuries and also help in the rehabilitation of chronic neck and upper back pain [15].
- h) Self- myofacial exercises (with foam ball and stability ball) provide significant relief from chronic neck, back, and shoulder pain that is often associated with practicing dentistry [29].

Four-handed dentistry

The principles of four-handed dentistry are:

- a) Treatments are planned in advance in a logical sequence.
- b) Instruments and equipments used are based on ergonomic principles.
- c) The operator, assistant, and patient are comfortably seated in balanced posture.
- d) Motion economy is practiced.

- e) Equipment and instruments should be centered around the assistant.
- f) Instruments and materials should be delivered and retrieved by the assistant without the operator having to shift focal length or leave the finger rest.
- g) Instruments and materials are transferred in the transfer zone only.

Dental assistants create a more efficient environment for the operator by eliminating unnecessary motion; decreasing twisting and turning movement; decreasing long reaches and unbalanced posture [17].

1. Few recommendations

- a) Formulating a prevention strategy by promoting training on both ergonomics practices and stress reduction in dental schools as a preventive measure. Also, including a separate course on ergonomics in the dental curriculum and periodically evaluating the ergonomic practices by students.
- b) Promoting continuing dental education programs on dental ergonomics for the clinicians and also periodic screening for MSDs-related symptoms to diagnose it early and treat promptly.
- c) Formulating global guidelines for designing and developing ergonomic dental equipment and also setting up an international monitoring agency to prevent manufacturing and sale of non-ergonomic dental equipment.
- d) Combining ergonomic interventions with health promotion activities and evaluating the outcomes [16].

CONCLUSION

Dentistry, particularly the practice of general dentistry, is a high risk profession for the development of musculoskeletal disorders as it requires high visual demands and prolonged static postures. The work-related musculoskeletal disorders among dentists not only decrease their

efficiency but are also a major reason for ill health retirement.

Ergonomics have come into the profession in a big way. A thorough understanding of ergonomics is essential to know about the musculoskeletal problems that could arise because of improper ergonomics in dentistry. Recognition of these musculoskeletal diseases at early stages and prompt treatment will help in reversing the disease process and preventing various disabilities. A pioneer in the field of dental ergonomics is Bethany Valachi who has dedicated a website for ergonomic practices in dentistry ([www. posturedontics.com](http://www.posturedontics.com)) and written numerous articles in this field.

Right ergonomics practices along with regular exercises, relaxation techniques (meditation, yoga and aerobics), and proper nutrition help us combat stress and conserve the productive energy. It thereby increases comfort, improves the quality of life, ultimately leading to extended careers. Good ergonomic practices include improving working techniques, redesigning the workstation to promote neutral posture, visual aids, and designing of ergonomic instrumentation. Our career is based on the decisions we make and the actions we take.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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