
REVIEW ARTICLE

Ergonomics Made Easy in Dentistry: An Update

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ABSTRACT

Ergonomics is the art of researching human activity-related stress factors as well as associated strain. This technique has the supreme motive to obstruct musculoskeletal diseases associated with the work pattern of a person or the signs aggravating or predisposing to those factors. Continuous abnormal drifted or improper operating positions, hand motions with excessive exerted pressure, improper instrument handling, non-functional working area dimensions or designs & non-appropriate mode of operation with limited in-between relaxations are the most commonly encountered riskfactors. The introduction of ergonomic techniques to routine dental practice (dento-ergonomics) can help enhance the efficacy of the operator as well as avert unwanted accidental injuries. Several aspects have to be looked after like the operator's height, weight distribution, the design as well as the weight of the equipment used & the division of works along with functionality of the work-space design. Adaptation of ergonomic modalities to dentistry helps lengthen their attentiveness and dedication towards the field in serving the community by converting strenuous or aching jobs lesser nerve-racking. This review helps thorough understanding of the impact it has on the dental professional's health by preventing unnecessary fatigue with enhanced productivity & minimal work-associated diseases in a long run.

Keywords: Ergonomics, Musculoskeletal disorders, Dentistry

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INTRODUCTION

Ergonomics-the term is derived from the Greek words "ergon" means work and "omics" means natural law. This term Ergonomics was coined by the great famous British psychologist Hywel Murrell. The pillar stone of the Society of Ergonomics was kept in 1949 at United Kingdom's Admiralty. The International Ergonomics Association (IEA) has defined ergonomics as: ERGONOMICS (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

Focusing on the improvement in the working environment through preventive measures promoting good health of the practitioner will definitely prove as a great boon in the field of dentistry. The discomfort felt by the musculoskeletal disorders like unbearable pain in the wrist and palm (carpel tunnel syndrome), persistent and repeated pain in the joints, muscles & back and neck region gets aggravated by the movements created repeatedly during dental procedures. The pain is also related to the long awkward or forced body postures during the dental treatment. Dental profession among others is the most vulnerable profession reported with relatively higher incidence of wrist, neck and joint pain. [1,2]

Causes of musculoskeletal disorders:

Pain intensity is directly proportional to the patients treated in a specific day and with the dentist's height[7]. It was also found that the stiffness frequency varies according to age in neck and hip/thigh, working hours in a day in relation to hand, and with patients treated in case of wrist. Repeated

movements and extended awkward positions can be the root cause of muscle damage, ligament tear and joint injury [8, 9].

The age of the dentist, gender of the professional, and overall general health status are related with chronic discomfort complaints as well as associated overall health care. Pain in the back is more correlated with sickness leaves than shoulder or neck pain respectively. Symptoms such as rotator cuff tendonitis, carpal tunnel syndrome (CTS), thoracic outlet syndrome, ulnar nerve entrapment, tenosynovitis, pronator syndrome, and tendonitis may occur among all dental professionals [10]. Back related pain is most commonly noticed amongst dental professionals worldwide followed with neck, feet or ankle pain.

Strategies to prevent work-related musculoskeletal disorders

There are four curvatures in the human spine (fig 1): Lumbar lordosis, Cervical lordosis, Sacral kyphosis and Thoracic kyphosis.

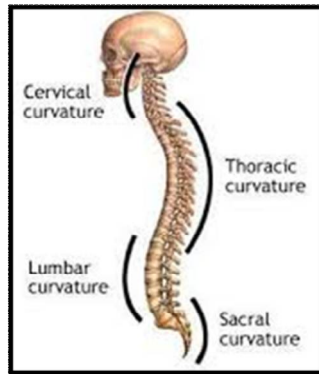


Fig1: Curves of human spine

The lumbar curve in the human spine generally flattens up when a dental professional sits and bends in the forward direction toward the patient while working. The human spine is not provided with any support by associated bony structures; therefore, excess pressure is directly directed on lower back region, which leads to tension build-up and muscle spasm or pain. The thighs of the dental service provider sloping in downwards direction often helps in maintaining the original operator's lower back curve without disruption, reduce the low back muscle spasm and thus reduce the associated lower back pain.

When the dental professional is in a seated position, the main component of overall body pressure is directly shifted to dental operator's chair & some to the back rest, floor and armrests respectively. The most effective way to decrease pressure or strain in the lower back is to operate on the concerned patient in a standing position.

A 120 degrees' inclination in the operator's backrest along with a lumbar support of approximately **5cm** is the ideal combination in order to prevent or minimize strain in the lower back of the dental professional. The angle between the operator's backrest and operating seat is the inclination angle which is supposed to be 120 degrees ideally. The lumbar support is the support provided by the operator's chair to the lumbar in the dental professional by sticking outwards which is supposed to be ideally 5cm.

ERGONOMICS RELATED INJURIES

Cumulative trauma disorders (CTDS) are disorders occurring as a result of repeated painful biomechanical strain in areas encompassing wrists, hands, elbows, back, neck region, or shoulders. Utmost commonly associated disorders are lower back pain and Carpal tunnel syndrome (fig 2) respectively. Pain in the lower back is the most common causative agent of domestic or occupational disability, with a prevalence rate of 1:2 among the dental professionals and 1:7 in the overall general population. Carpal Tunnel Syndrome (CTS) is defined as a symptomatic compression of the median nerve within the carpal tunnel, which is the space between the carpal bones on the dorsal aspect of the wrist and the transverse carpal ligament on the palmar aspect of the wrist respectively.

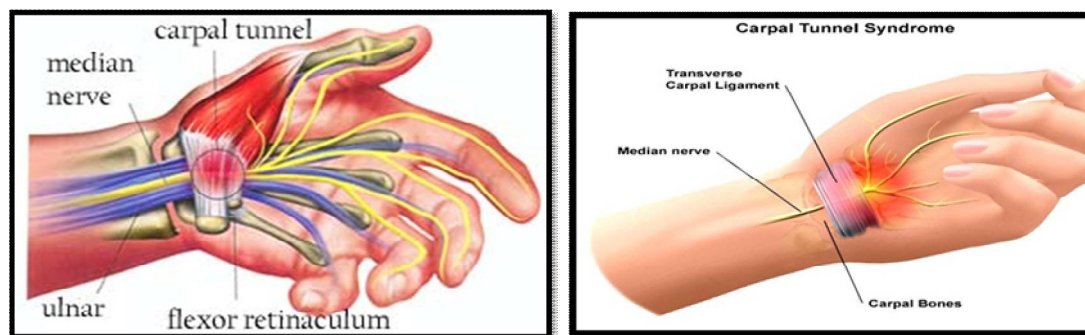


Fig 2: Carpel tunnel syndrome

In 1995 a survey was conducted on musculoskeletal disorders often noticed among the dental hygienists in areas of Canada & confirmed that the heavy calculus subjects in a day, “clock” position of the operator in the chair or the experience of clinical practice were distinct predictive factors of future CTS among the subjects.

ASSOCIATED RISK FACTORS

1. **Awkward positions or postures:** It refers to the operator’s working position that diverted from the normal position during performance of specific work-tasks like twisting, extended reaching, or kneeling.
2. **Contact stress:** Resulting due to repeated or occasional touching of the sensitive bodily tissues with sharp, hard objects like resting operator’s wrist on desk edge, or an instrument handle being pressed into the operator’s fingers/palms.
3. **Force:** The physical effort which is required in order of maintaining the proper balance of dental instruments, or performing functions like carrying, heavy lifting, pushing or pulling respectively.
4. **Age-related changes:** With increasing age the eyesight capacities of the operator decreases. Similarly, the reaction time also lengthens along with decreasing workload bearing capacity. The temperature associated discomfort also gradually increases with age.
5. **Static postures:** It refers to holding a fixed or permanent posture or position like firmly gripping operating tools that cannot be kept down or being in a standing position for continued long durations.
6. **Repetition:** Continuous performance of the same action in a repeated manner for a prolonged time-period with very little deviation like continuous typing, multiple same sitting restorations or root canal treatments, scaling or root planning and teeth polishing among dental professionals.

AIM OF APPLICATION OF ERGONOMICS IN WORK PLACE

- a) Reduced risk of operator’s carpel tunnel syndrome.
- b) Increased safety & efficiency of the dental professional.
- c) Improved work quality by the dentist.
- d) Reduced errors and fatigue.

Operator chair ergonomic guidelines

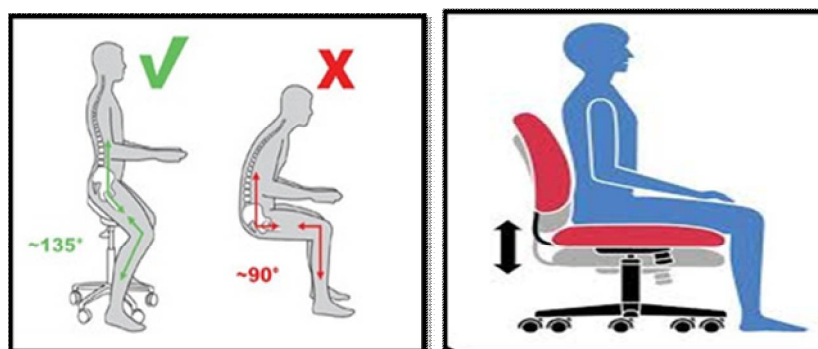


Fig 3: Operator chair ergonomic guidelines

For the optimal control the dentist should be in the balanced reference posture (fig 3). The balanced reference posture of the clinician who is prepared to perform acts of great precision with great control with the least amount of physical stress. Determination of posture is based on the reception of internal stimuli, primarily from the muscles, joints, tendons and organs that relates a person to actions and surroundings.

CHARACTERISTICS OF BALANCED REFERENCE POSTURE

- a) Head- In the least strained position vertically and horizontally.
- b) Shoulders- Loose hanging free vertically.
- c) Upper arms- Loose hanging free vertically.
- d) Lower arms- In the least strained position vertically and horizontally; in line with the palms.
- e) Wrists- Neither flexed nor extended.
- f) Hands- Near the level of the apex of the heart; palms vertical; fingers relaxed and flexed; index finger near the median plane.
- g) Back- Straight and erect.
- h) Buttocks- Weight distributed evenly.
- i) Thighs- Clear and free of distracting contracts; separated and unstrained; front of the thighs sloping downwards from trunk to knees.
- j) Legs- Clear and free of distracting contracts.
- k) Feet- Clear and free of distracting contracts.

Arm rests helps the operator ergonomically by diverting the entire body's force not entirely on the back rest or operator's chair, but putting away some pressure onto the operator's armrests. Arm rests help move the required fulcrum to operator's elbow, thus moving the work pressure onto the small motor muscles in order to perform precise work. Armrests are to be adjusted in position and desired height to ensure that operator's shoulders are not overstrained.

ERGONOMIC GUIDELINES FOR THE ASSISTANT

a) Four handed dentistry:

It is the method of a team-work comprising of extremely skilled clinical or dental practitioners working together in an ergonomically designed environment to improve productivity of the dental team, improve the quality of care for dental patient, while protecting the physical well-being of the operating team.

- b) True four-handed dentistry technique is not meant for handing over instruments from one to other person nor is it "hurry-up" dental practice.
- c) It reduces stress and strain on the operator where the dental professional exchanges dental instruments and equipments with the assisting personnel, who evacuates the oral cavity, and prepares required dental materials.
- d) Actual four-handed dentistry method is the way to work in a smarter fashion, and not harder.

ERGONOMIC GUIDELINES FOR THE PATIENT

- a) If the clinician is to maintain a balanced position or posture, the concerned subject must be placed in the sleeping position, parallel to floor.
- b) Top of the patient's head should be at the upper edge of the head rest.
- c) The height of the patient's chair should be set in such a manner that the patient's oral cavity is at height of clinicians optimal control point, approximately at the clinician's heart level.

Positioning variables:

- a) **Clinician** – The clinician can move around the patients head to access various areas of the oral cavity.
- b) **Patient head tilt**- The patients head can be tilted in the anterior or posterior plane for better access.
- c) **Patient head Rotation**-Patient can also rotate the head to right or left for better access.
- d) **Intraoral opening**-The amount of intraoral opening or width of opening is another variable for accessibility. For access to most areas of oral cavity, maximum opening is desirable, but for accessing the buccal surfaces of the posterior teeth, the task will be easier if the patient closes the mouth slightly.
- e) **Patient support height**-The patients support height should be adjusted according to the optimum control point.

EQUIPMENT PLACEMENT

Clinician should be aware of the impact of equipment placement on posture and control and, whenever possible should maintain ideal placement.

- 1) **Instrument tray position:** The tray should be placed on the dominant side of the clinician beside the patient's head in order to minimize unnecessary by the clinician when reaching for the instrument tray.
- 2) **Instrument placement:** Instrument should be placed on the tray horizontally and in the logical order of ease of pickup. This will prevent constant distortion of the clinician wrist and confused searching when reaching for instruments.
- 3) **Light position:** The light should be positioned directly over the patient's oral cavity within the reach of the clinician. It should be placed high enough that the clinician and the patient will not inadvertently hit their heads on the light.
- 4) **Hand piece or chair foot control:** Any hand piece and chair foot control should be placed just out of the normal range of foot movement. This will prevent inadvertent activation of the hand piece, yet it will allow for intentional activation with the minimum of strain on the clinician.

PREVENTIVE MEASURES

1. The ergonomics considerations for prolonged good health without injury are the support of limbs, use of operating instruments with larger handles as well as operating on a mechanical adjustable chair with an adjustable back rest. [12]
2. Another important feature to prevent forced awkward back and neck positions are correct and proper positioning of the patient along with the use of indirect visibility while operating.
3. Proper and adequate lighting and use of microscopes & magnifying loupes are also helpful in reducing fatigue and increasing operator's productivity.
4. The everyday planning of the work schedule should provide a break for the opposite muscular groups to maintain productive work. The applied occupational and environmental hygiene guidelines recommend at least six min of rest every hour for professionals to perform repetitive movements. [13]
5. Between-work recommended breaks are:
 - a) **Frequent gaps** and exercises (arms relaxing, shaking followed by dropping for an average of 15 seconds periods).
 - b) Timely breaks between consecutive patients (dental professional should perform actions or movements opposing to those generally done while prolonged work, for an average of 2-3 mins).
 - c) Breaks for stress recovery (time period of 10-15 mins every 2-3 hours).
6. The key role of exercise should be taken into account. Exercise will improve muscular strength, flexibility, stamina, tendon strength, co-ordination of movements, decreases the risk of overburdening, and degenerative changes in locomotor organs. Exercises should be given individually and referred to the physiotherapist as possible.
7. **Open hip angle** helps in preventing musculoskeletal disorders which can be done by:
 - a) **Operator Tilted seat pattern:** It helps open the hip angle by approximately 110 degrees. Retrofitting a non-tilted seat like the Fit-sit ergonomic cushion.
 - b) **Saddle stools:** This type of seat opens the angle of hip by approximately 135 degrees. It is an ideal option in constricted operator areas. Dental professional is thus midway between sitting position or standing, therefore lower waist pain issue is even reduced than when the operator is seated in an often used normal operating chair.
8. **Forward adjusted backrest:** The height has to be adjusted so that the most convex part nests in the operator's lower back curve which in turn will reduce the back muscle straining activity. It subsequently provides body's repair rate to progress beyond the damage ratio.
9. **Too short cylinder should be avoided:** If doctors stool is adjusted in lower position, hip angle becomes acute, weight is transferred to a small area under the sit bones, rather than spreading out over the back of the legs, leading to a compression of abdominal organs and flattening of spine and low back pain.
10. **Shorter working distance (WD) should be avoided:** It is defined as the distance from the doctor's eyes to the occlusal plane of the patient. Lower back/waist pain is mostly noticed when patient position is elevated or if the operator hunches over while working. Using of indirect visibility is normally recommended in order to avoid awkward operator positions.
11. **Proper adjustment of the patient's head rest:** If it is elongated and more pronounced, dental professional will have to hunch forward over the dead space of the head rest, thus leading to lower back pain. The patient should always be asked to scoot till the end of the dental chair's head rest .
12. **Instrument selection:** The design of the instrument should facilitate decreases in the exerted force as well as maintenance of the hand/wrist in an ergonomically normal position.

- a) **While purchasing Hand instruments:** compressible handles, hollow or resin round, knurled handles; lightweight hoses; activated easily should be prioritized.
 - b) **While buying Automatic hand pieces:** Lightweight and balanced hand pieces, (preferably cordless); with sufficient power and built-in light sources.
 - c) **In Syringes and dispensers:** Appropriate lumen size; easily cleanable; knurled handles with no finger cut-outs; easily activated and placed.
13. **Positioning of the Rheostat:** It should be placed in close proximity to the professional in such a way that the operator's knee is approx. forming a 90-100 degrees' angle. If it is outside this horizon, the operator must slightly shift his/her weight to its side, thus leads to asymmetrical strain on the back causing lower back/waist pain. It should be switched from one to other foot 2-3 times daily between performing any dental procedure.
14. **Magnifying systems:** The goal is to improve neck position and provide clear vision. Even 20-degree head bend forward leads to straightening or flattening of low back curve and hence lowers the incidence of back/waist pain. Usage of magnification system utilizes a 0-degree forward head bend and an extra oral camera to display image on a Liquid-crystal display screen.
15. **Stretches:** Performed mainly towards the tight side during working through the entire day.
- a) **The un-twister stretch:** Legs are placed in tripod position; and the operator should bend to the left side. Left elbow should be rested on the operator's left knee. The right arm is supposed to be stretched overhead and looked towards the roof. It should be held in position for about 2-4 breath cycles and repeated.
 - b) **Trunk rotation stretch:** The operator is supposed to sit straight crossing the right leg over the left. The left forearm is to be placed on the right thigh and trunk has to be turned to the right side.
 - c) **The reversal:** The operator's wrists should be supported on the hips and gradually leaned in the backward direction. The head should not be overextended. It should be held in place for 2-4 breaths and repeated.
 - d) **Weight control:** With every addition of 10 pounds of weight, generally 100 pounds of force is directed towards the operator's lower back.
 - e) **Dentist micro breaks:** The dental professional can take a break while doing consecutive dental procedures to do stretches when the assisting personnel light cures, or when waiting for the an aesthetic agent to act, when the assistant helps mix cements or apply periodontal packs or dressings.
 - f) **Pointer dog:** This exercise is the most effective exercise among the lot. It has to be started on knees & hands keeping the trunk stable. The navel has to be pulled towards the spine. Arm has to be lifted along with the opposing leg simultaneously, held in position for 5-8 seconds and then lowered.
 - g) **Lumbar roll exercise:** The arms are to be extended on the floor at the height of the shoulder with palms up. The ball is to be rolled to the left side without lifting shoulders from ground and then the movement is to be repeated on the right side as well. Wearing long sleeved clothes are recommended in case of colder room temperature to keep the muscles warm.

EPIDEMIOLOGICAL STUDIES

Marshall *et al.*, [14] described the distribution & prevalence of signs and symptoms of musculoskeletal disorders among dentist in Australia and shows that 82% of subjects showed signs of one or more musculoskeletal symptoms. 64% of them mentioned suffering from pain and 58% headaches. The most severe symptoms noted during the study period were pain 39% and migraines 25%. Akesson *et al.*, [15] described that female dentist and dental hygienist showed elevated rates of symptoms of the neck, shoulder and wrist injury. Male dental professionals had increased frequencies of shoulder & neck symptoms in comparison to the referents. Rundkrantz *et al.*, [16] also studied the prevalence & occurrence of Pain and work-related disorders among dental professionals. Incidence of pain and discomfort is seen to have increased with increasing work time.

CONCLUSION

Knowledge about the scope of ergonomics and prophylactic measures during working should be imparted in the graduation studies and various forms of training. The dental clinic should be designed so as to ensure a better work with healthy and long lasting career. Lastly, the beneficial function of physical activity including stretches and exercises is a crucial key factor and should also be considered. Personalised rehabilitation exercise, stretching and regular aerobic activity should be done.

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