



Review Article

ERGONOMICS AND MUSCULO-SKELETAL DISORDERS IN DENTISTRY

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Received May 22, 2015; Accepted July 03, 2015; Published September 22, 2015;

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Cite This Article: Sabarigirinathan, C., Vinayagavel, K., Rupkumar, P., Sriram Prabhu, G., Narayanan, S., Venkata Seetha Lakshmi, K. (2015). Ergonomics and musculo-skeletal disorders in dentistry. International Journal of Medicine & Health Research, 1(2)1-12

ABSTRACT

In spite of recent advances in technologies, occupational health related problems are more prevalent in modern day dentistry. Musculo-skeletal disorders are one among them that frequently haunt and disable many of the contemporary dentists. The proportion of reporting of musculo-skeletal pain and seeking of medical intervention for the same are on an increase among the dentists and the dental staffs. Dental procedures, sometimes, might be laborious needing constant focus of work in areas of difficult, minimal or restrained access in oral cavity. Dental procedures involve use of potentially dangerous instruments and materials that require proper handling and disposal as well as a good assistance from patient and the supporting dental staffs apart from the dentists. Dentists have to adopt necessary safety measures as these risks cannot be engineered out of dental office always. While abstaining from such risks, dentists also face stiff challenge of maintaining proper working posture to avoid any strained muscles. Musculo-skeletal disorders potentially handicap the dentists' health and inadvertently affect the quality of the dental practice. Proper use of the dental resources is an absolute necessity for the dentists to keep such disorders at bay and avoid incurring considerable impact on economics and good will of dental practices. It is of paramount importance for dentists to be updated with information regarding tackling of these health problems and wise use of necessary innovations. By learning the art of coping strategies for prevention of musculo-skeletal disorders, dentists can tread a fine line between maintaining health, income, technical and professional standards.

KEYWORDS: Musculo-skeletal pain, occupational health problems, ergonomics, musculo-skeletal disorders, posture, dental professionals, static postures, neutral positions

INTRODUCTION

The definition of ergonomics is, "Ergo" means work and "Nomoi" means natural laws or systems. It is an applied science concerned with designing and arranging things people use, so that the people and things interact most efficiently and safely. Basically, ergonomics is the science of fitting workplace conditions and job demands to the capabilities of workers. (U.S. Dept. of Health). Ergonomic conditions are simply the safest, most efficient, and easiest way to work. Improving the ergonomic delivery of dental

services and accounting for working conditions in dental offices enhance the well-being and safety of patients, staff, and practitioners. Ergonomics is designing, safety, healthy conditions, comfortness and creating efficient workplace both for users and patients. [1]

Goals



The goals of ergonomics are to improve worker performance so that they can work more effectively to create a healthy and safe working environment thus increasing productivity and job satisfaction, to enhance performance by eliminating unnecessary effort, to reduce opportunities for overexertion injury and to improve comfort by curtailing the development of fatigue.

Consequences of poor design

Include, fatigue, discomfort, illness/injury, absenteeism, errors, lower productivity and customer dissatisfaction.

Benefits of an ergonomic program

Decreased injuries, illnesses, and workers' compensation costs, increased efficiency at work, increased physical well being, decreased absenteeism and turnover and increase in employee morale.

Ergonomic related injuries

- CTD's (Cumulative Trauma Disorders)
- RSI's (Repetitive Stress Injuries)
- RMI's (Repetitive Motion Injuries)
- MSD's (Musculo-skeletal Disorders) affect muscles, tendons, nerves, joints and spinal disks.
- MSDs are medical conditions that develop gradually over a period of time due to repetitive exposure, overexertion of muscles over a prolonged period of time

Reasons for early retirement among dentists

- Musculoskeletal Disorders (29.5%)
- Cardiovascular Disease (21.2%)
- Neurotic Symptoms (16.5%)
- Tumors (7.6%)
- Diseases of the Nervous System (6.1%)

Musculo-skeletal disorders (MSD)

Include a group of conditions that involve, muscles tendons, nerves and supporting structures such as intervertebral discs [2, 3, 4, 5, 6].

TYPES OF MSD

Neck and shoulder disorders

- Myofascial Pain Disorder
- Cervical Spondylolysis
- Thoracic Outlet Syndrome
- Rotator Cuff Tendinitis/Tears

Back disorders

- Herniated Spinal Disc
- Lower Back Pain
- Sciatica

Hand and wrist disorders

- DeQuervain's Disease
- Trigger Finger
- Carpal Tunnel Syndrome
- Guyon's Syndrome
- Cubital Tunnel Syndrome
- Hand-Arm Vibration Syndrome
- Raynaud's Phenomenon

CHARACTERISTICS OF MSD

They occur from a single event or many small injuries and will take weeks, months, or years to develop. Generally, produces no symptoms in early stages, but show symptoms after injury has occurred. The contributing factors may occur at home and at work. Usually, same MSD may differ in severity from person to person doing a similar task.

- **Signs**
- Decreased range of motion
- Deformity
- Decreased grip strength
- Loss of muscle function

Symptoms

- Pain
- Numbness
- Tingling
- Burning
- Cramping
- Stiffness

Predisposing factors

- Age
- Arthritis
- Renal diseases
- Hormonal imbalances
- Diabetes
- Hypothyroidism

FACTORS CONTRIBUTING TO MSD

Instrument grasping

Figure 1: Strained and prolonged instrument grasping



Forceful hand exertions, grasping small instruments for prolonged periods, repetitive movements while performing dental procedures. e.g., scaling, root planing, polishing

Fixed or awkward postures

Figure 2: Fixed/awkward postures of neck, back, shoulder posture, hand/wrist positions, standing/sitting, operatory organization, patient positioning



Reasons for stress in dental practice

- Weak postural position
- Prolonged static position
- Poor equipment \ adjustment
- Inadequate lightning
- Poor flexibility
- Too much force exertion
- Repetitive motion
- Improper positioning
- Awkward position
- Mental stress

- Posture\positioning
- Work practices
- Personal protective equipment
- Chair side stretching exercise

Provide sufficient space

Awkward bending, twisting, and reaching places stress on the musculoskeletal system and can lead to discomfort. Permanently place equipment used in every clinical procedure within comfortable reach (within 20 inches of the front of the body), use mobile carts for less commonly used equipment, allows convenient positioning when required, provide a clear line of sight to the oral cavity and all required equipment, maintain a neutral, balanced position—position of an appendage when it is neither moved away from nor directed toward the body's midline; it also should not be laterally turned or twisted.

What factors contribute to MSD?

- Repetitive motions (e.g., scaling, polishing)
- Static neck, back, and shoulder postures
- Grasping small instruments for prolonged periods
- Prolonged use of vibrating hand tools

Accommodate individual preferences

Individuals vary in size, shape, training, and experience. Ensure equipment and work areas allow flexibility; examples may include, allows right- or left-handed use, allows different working postures, provides a choice in methods used.

Applying ergonomics to dentistry

- Provide sufficient space
- Accommodate Individual Preferences
- Reduce physical effort
- Instrument design
- Patient chair
- Operator chair



Reduce physical effort

Avoid bent or unnatural postures. Ideally, equipment should allow work in a relaxed and well-balanced position. DHCP should adjust equipment to the appropriate height. Position the patient to allow easy access from the desired position. Use reasonable operating forces, minimize repetitions which reduces overall physical effort required by a task, minimize sustained effort, brief but frequent rest/pauses can minimize fatigue and enhance productivity, try to incorporate a variety of different activities to shift musculoskeletal demands from one part of the body to another.

Operator position

Dental operators should assume their best position that is through the least-strained, blind folded movements of the arms, determine the position of the instrument holders. This position should allow pick-up of instruments and devices from a stable location and at an angle that requires the least positioning of the instrument once it is contacted.

Static zone

It is a zone of least activity. Instruments that are infrequently used such as the blood pressure equipment, portable curing light or the assistant's mobile cabinet when not in use can be stored in this area.

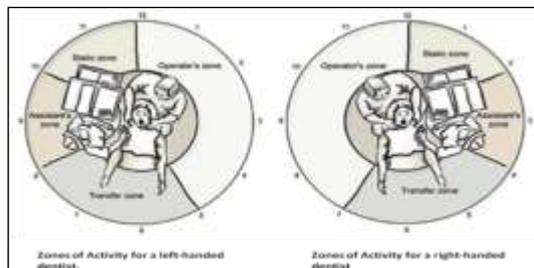
Zones of activity

The dental team must be aware of special functional spatial relationships around the patient at chair side. The work area around the patient is divided into four "zones of activity." Zones of activity are identified using the patient's face as the face of a clock. The four zones are:

- operator's zone,
- assistant's zone,
- transfer zone,
- static zone.

The operator's zone for a right-handed operator extends from 7 to 12 o'clock, the assistant's zone from 2 to 4 o'clock, the instrument transfer zone from 4 to 7 o'clock, and the static zone from 12 to 2 o'clock. The operator changes position dependent upon the dental arch and tooth being treated. The assistant seldom moves much in the zone of activity, but may find it necessary to raise the operating stool when working on the mandibular arch to improve the line of sight into the oral cavity.

Figure 3: Zones of activity



Operator position

Instrument pick-up zone extends laterally and downward from the patient's mouth within the reach range of the operator and without compromising the operator's orbiting range. The "orbiting range" -12:30 to 10-right-handed operators. 2 o'clock to 11 o'clock- left-handed operators.

Operator's chair

Figure 4: Operator's chair



Operator's chair is padded adequately to support the operator. It has seat surface which may be flat or contoured (saddle type). Base is broad with at least four casters on the stool is recommended to prevent tipping and allow mobility. Seat should be adjustable from 14-21 inches. A lever located beneath the seat is used to activate a hydraulic system for raising or lowering stool height. Back rest should be easily adjusted forward to adjust to the operator lumbar curve in a balanced

seated upright position. Arm rests are useful in reducing neck pain and also reduce low back pain for operators of all height. Tilting seat pans help to maintain low back curve, thereby lowering lumbar intradiscal pressures, reducing lumbar muscle strain, thus reducing low back pain.

Tilting seat pan

When seated on a flat seat pan with thighs parallel to the floor, your pelvis rolls backward and the lumbar curve flattens. Flattening of the lumbar curve has detrimental effects on both the spinal musculature and discs. Research suggests that the most optimal seated posture for operators is hips higher than the knees, which requires a seat pan design that tilts slightly downward from back to front. This slight downward inclination of the seat pan (from 10° to 15°) helps facilitate the lumbar curve in the low back. This increases the hip angle to 105° to 125°, which results in a reduction of muscle activity and disc pressure in the lower back and may also enable a closer position to the patient for the operator.

Seat contour

The seat contour greatly impacts comfort and support. The front edge of the seat should be padded and have a “waterfall” edge. This feature is especially important to reduce pressure on the posterior thigh’s blood vessels when sitting with your thighs sloping downward.

Seat depth

Figure 5:Seat depth and back rest



Dental seat pans range from 14 to 18 inches deep and should support most of your thigh. When seated all the way back on the seat and in contact with the backrest, the operator should be able to easily fit at least 3 finger widths behind the back of the knee without touching the seat. If the seat pan is too long, modifications should be made to accommodate the shorter dentist

Back rest

A backrest with good lumbar support helps maintain the spinal curve when sitting. The lumbar support should be convex to support your low-back curve. It needs only to be approximately 8 inches in height. This is an especially important feature with non tilting seat pans, which tend to flatten the low-back curve. Lumbar support helps preserve the lumbar curve, reducing muscle activity, disc pressure, as well as back and leg pain.

Arm rests

Studies support the use of armrests in the prevention of neck, back, and shoulder pain. These are especially important for endodontists and dentists who are forced to reach forward with the arms more than 15° due to a protruding abdomen (ie, pregnancy) or a large chest. Types of arm rests are:

- fixed-adjustable armrests
- swiveling
- telescoping armrests

Proper height adjustment of the armrest is essential, since adjusting the armrest too high or too low can lead to a worsening of neck and shoulder pain. Positioning the armrests too far forward can encourage the operator to lean forward, thus compromising operator posture.



Saddle-style stools

Saddle stools open the hip angle to about 130° and position the pelvis to optimally balance the spine, decreasing muscular strain. Features a highly padded, medium width tilting seat. It is useful in gaining close proximity at the 9-10 clock positions for short operators, and in confined operatory spaces. Thighs point down at a 45 degree angle, tilting the pelvis to a near neutral position, as in standing. This allows the lower back and upper body to find its relaxed, natural posture without the need for a backrest. Advantage includes places the pelvis in a near-neutral position. This is why backrests are considered optional on saddle stools. Great for confined areas due to their very low profile. Allow close proximity to patient chairs with thick upper backrests

Figure 6:Saddle type stools



Disadvantage is that places more compression on the peritoneal area and should be carefully evaluated for suitability to the operator.

Orasoptic chair

It has replaced the old, larger backrest with a smaller backrest with convex, supportive lumbar support to improve posture. It fits the lumbar area very well and conforms to the natural spinal curves. Seat pan size (17"D, 17"W) works very well for medium to tall operators. It has synchronized tilt of seat and backrest. Has movable, fixed armrests are highly adjustable in all planes, and stay fixed in place very well when knobs are tightened. Provides a good, natural and relaxed posture, relaxes shoulder area tension by allowing lower positioning of the patient, relieves or eliminating lower back pain, prevents fatigue and improves productivity, easy visibility into the mouth comes from leaning forward with a straight back.

Figure 7:: Orasoptic chair



Crown stool

It is an innovative hybrid between a traditional stool and saddle stool. Has triangle-shaped seat allows operators to sit at an ergonomically correct angle with thighs angled downward-without the expense of a tilting seat pan. This stool is especially well-designed for shorter operators.

Figure 8:Crown chair



Prosthetics labs

Lab technicians mentioned chronic back, shoulder & neck discomfort / pain during working at non-adjustable bench in obviously stressful static postures – with no forearm support nor bench edge padding. They affirm greatly increased comfort / decrease in back, shoulder & neck discomfort / pain. KAVO dental prosthesis lab benches offer ample forearm supports

and work piece support centering prosthesis directly below technician which optimizes spinal / neck / head vertical alignment.

Dental chair

The dental chair is the center of activity for all treatment procedures. Its design is critical to successful treatment. It should be designed such that good access to the patient's oral cavity is obtained while the operator team is seated in a comfortable position.

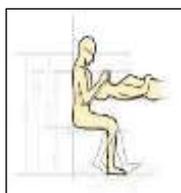
Requirements in the dental chair

It should allow the patient to be placed in a supine position. The back of the chair should be thin and narrow in the headrest area, this allows the dentist and the assistant to position themselves as close to the patient as possible without leaning and reaching to gain access. The chair base must allow the patient to be lowered so that the patients head is located on the lap of the dentist. It must be lowered to a position 14-16 inches above the floor. The patient should be comfortable without the dentist sacrificing access and visibility. The controls should be located such that it is reached conveniently. Placing the control that raises and lowers the chair on the chair base so that it can be activated by foot ,and the back and seat tilts control should be located along the side of the head rest area is ideal for easy access.

Posture/positioning

The goal is to avoid static and/or awkward positions. The potential strategies include, position patient so that operator's elbows are elevated no more than 30 degrees, adjust patient chair when accessing different quadrants, alternate between standing and sitting.

Figure 9:Posture/positioning



Instrument design

The goal is to reduce force exertion; maintain hand/wrist in neutral position (no wrist bend). The Considerations are, overall shape/size, handle shape/size, weight, balance, maneuverability, ease of operation and ease of maintenance.

Hand instruments

When selecting instruments look for hollow or resin handles, round, textured/grooves, or compressible handles, carbon-steel construction, lighter, well-balanced instruments with thicker, larger handles and textured or cushioned grips to reduce the force needed in dental procedures, sharp, color-coding may make instrument identification easier, longer cords, tubing, and attachments to provide greater mobility, flexibility, and decreased resistance during use.

Dental Hand pieces

When selecting hand pieces look for lightweight, balanced models, sufficient power, built-in light sources, angled vs. straight-shank.



INSTRUMENT POSITION

Figure 10: Holding the Wrist in a Non-Neutral Position: The wrist is bent (flexed) while the fingers are being used



Figure 11: Tight Pinch Grip: The distal index finger joint is straight or hyperextended in a tight grip.



Figure 12: Work with wrist in neutral position, when possible. In a neutral position, the wrist is held straight or in a slight extension.



Figure 13: Use a more relaxed grip, when possible. The distal finger joint is slightly flexed in a relaxed grip.



To extra long working distances for very tall operators (more than 20 inches).

Lighting

The goal is to produce even, shadow-free, color-corrected illumination concentrated on operating field, overhead light switch readily accessible, hand mirrors can be used to provide light intraorally, fiberoptics for handpieces add concentrated lighting to the operating field.

Illumination

Inadequate lighting can also lead to contorted postures to view shadowed areas of the mouth. Advises positioning the operatory light parallel to, or within 15° of, the operator's line of sight.

Delivery systems

Each delivery system has its pros and cons and can profoundly impact the operator's musculoskeletal health and productivity—either positively or negatively. Some are better suited to 4-handed operatories, some work best for taller operators.

Rear-delivery systems

All clinical instruments behind the patient, freeing up space for other larger pieces of equipment in the operatory. They also keep the equipment out of view of the patient which will decrease anxiety. Functionally, rear delivery works fairly well when true 4-handed dentistry is practiced. More often encourage operators to extensively, lean, or twist their torsos to retrieve instruments from behind the patient's head, which can contribute to low-back pain. Disadvantages are in some rear-delivery systems limit access from 11 to 12 o'clock positions, which generally offer the best ergonomic access during a procedure. But it is the poorest method of delivery in 2-hand function.

Side-delivery systems

These systems require less trunk-twisting than rear delivery for the doctor to retrieve instruments, Since the assistant cannot reach the instruments, productivity may often be compromised. Dentist must also remember to squarely face the system when changing burs, rather than sustaining a twisted posture. Side-delivery systems work especially well in 2-handed operatories. One problem with dentists who use side delivery, is the tendency to "lock" into one working position relative to the patient. Doing this will tend to overwork/fatigue certain areas of the body and can lead to pain.

Over-the-patient delivery systems

These delivery systems allow the doctor to move freely from the 8 to 12 o'clock positions around the patient's head. The unit is on an arm that extends over the chest of the patient, so that handpieces and other instruments are within easy reach for both dentist and assistant, thus minimizing movement and shift of vision. However, this

Working distance

The distance from the eyes to the working area. With patient's mouth at or 4 cm above elbow level. Working distances will vary for shorter operators (14 inches or less).

system is highly visible and in close proximity to the patient. It may also be bumped by the patient, making it undesirable for most pedodontic offices. For operators with shorter torsos, the system may require repeated upward reaching at the shoulder, an ergonomic risk factor for shoulder pain. Also, for your assistant's health, do not position the system too far down the patient's stomach, since this will cause your assistant to have to twist to retrieve instruments.

Trans thorax delivery systems

These delivery systems are often confused with over-the-patient systems, however, the placement and usage of each differs significantly; namely there is no support arm that extends over the patient and the handpiece tubing is transferred and retracted along the top of the unit cover. The transthorax unit design is positioned at the patient's left side and designed to fully utilize the expanded duties (functions) of an assistant to maximize productivity. The assistant retrieves and transfers handpieces from the unit to the doctor. This allows the dentist his/her eyes focused on the operating site. This type of unit has been designed for the practice of true 4-handed dentistry.

Over-the-head delivery systems

Combining many of the benefits of over-the-patient and rear-delivery systems, over-the-head systems. Allow the operator the ability to practice from the 7 to 1 o'clock positions. Supplies are in an ideal position for access to

Four-handed dentistry

the assistant and handpieces are more accessible than with rear-delivery layouts. This reduces the ergonomic challenges when in 2-hand function. Additionally, over-the-head layouts, when properly configured, convert from right- to left-hand function rapidly.

Magnification

The goal is to improve neck posture; provide clearer vision. When selecting magnification systems consider, working distance, depth of field, declination angle, convergence angle, magnification factor and lighting needs.

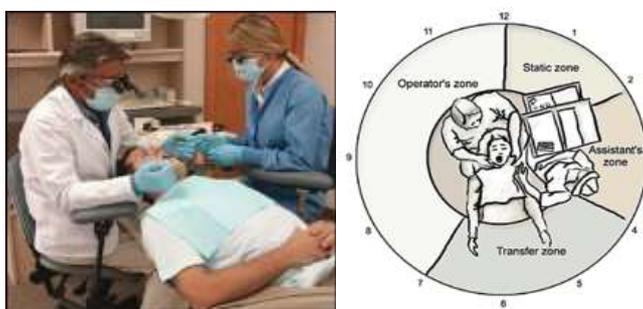
Scheduling

The goal is to provide sufficient recovery time to avoid muscular fatigue. The Potential strategies are increase treatment time for more difficult patients, alternate heavy and light calculus patients within a schedule, vary procedures within the same appointment, shorten patient's recall interval.

Work practices

Maintain neutral posture; reduce force requirements, ensure instruments are sharpened, well-maintained, use automatic hand pieces instead of manual instruments wherever possible, use full-arm strokes rather than wrist strokes, modify procedures to reduce the repetitive force and pressure exerted when using tools and equipments, exercise and fitness is an important element of overall health and prevention of musculoskeletal disorders.

Figure 14: Four handed dentistry concept



Four handed dentistry concept derives its name from the fact that the hands of both the dentist and the assistant are used to provide patient care. This method of practice is more efficient and reduces stress and fatigue for the dentist over an entire practice life span.

Four basic principles:

- Operating in a seated position
- Employing the skills of trained dental auxiliaries
- Organizing every component of dental practice
- Simplifying all tasks as much as possible

All instruments, equipment and materials for the patient's appointment are in the operatory and readily accessible by the assistant before the team is seated. The operator, assistant, and patient are comfortably seated in balanced posture. Motion economy is practiced. Instruments and materials should be delivered and retrieved by the assistant without the operator having to shift focal length or leave the finger rest. Instruments and materials are transferred in the transfer zone only. The operator assigns all legally delegable duties to qualified assistants based on the state's guidelines. Increases productivity and efficiency, decreases stress and strain from awkward posture, twisting and turning, and frequent, movement away from the operating field.

Basic ergonomic principles

Always maintain the neutral position, use the power position, stay within your reach zone, maintain and use the correct tools and equipment, provide adequate rest breaks, control and reduce the duration, frequency, and severity of exposures.

Posture

Always maintain the “S” curve in your spine, feet flat on the floor, knees and hips at a 90o angle, elbows at 90° angle – do not lean on elbows, shoulders relaxed and elbows close to body, head and neck in the upright position, hands and wrist in the neutral position.

Sitting basics

The height of the chair should be adjustable, seat pan depth allows clearance for knees, adjustable backrest with lumbar support, adjustable arm rests - height & width, chair tilt, seat pan angle and one chair does not fit all.

Relax and exercise

Figure 15: Neck exercises **Figure 16: Arm stretches**



Figure 17: Shoulder stretches **Figure 18: Finger stretches**

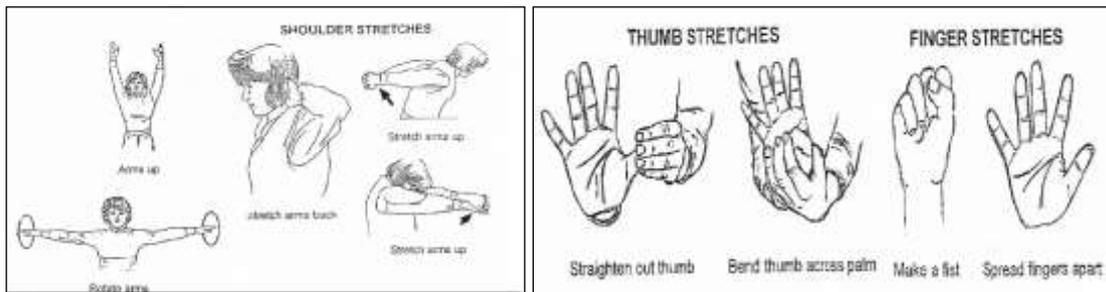


Figure 19: Wrist exercises

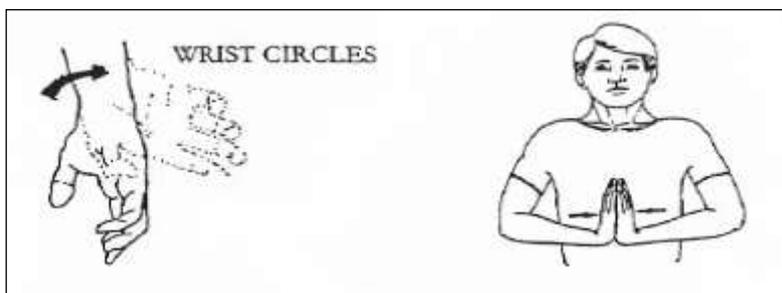


Figure 20: Upright posture and usage of loupes/mirrors

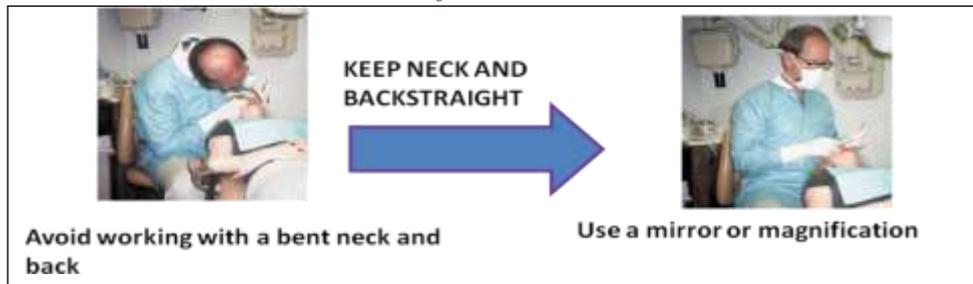


Figure 21: Arm positions

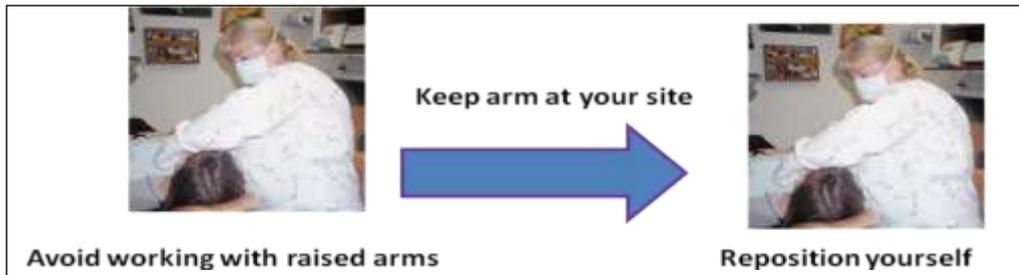


Figure 22: Correct wrist positions

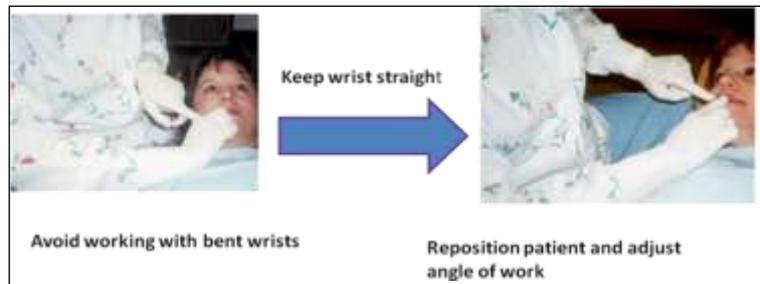
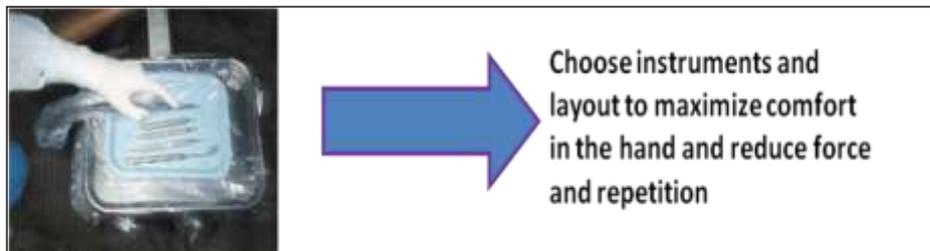


Figure 23: Proper arrangement of necessary instruments



Strategies for improved ergonomics

STRATEGY	METHOD / RATIONALE
Magnification	Magnification loupes
Patient positioning	Appropriate chair position, patient head angulations
Operator positioning	Use of clock positions, avoiding static postures, seated dentistry
Assistant positioning	Seated above operator eye level, hips and thighs parallel with patient's shoulder, avoiding static postures
Equipment	Designed and positioned to minimize bending and reaching, using stools with lumbar support
Instruments	Larger diameter handles, textured grip, balanced weight
Maintain good health	Exercise, nutrition, regular physicals

CONCLUSION

Work-related pain is common among dental professionals. The development of four-handed operatory working techniques has made delivery of dental care more efficient and productive. However, it also has contributed to an increase in PSPs among operators. Because this problem is multi-factorial, any possible solution should be multi-factorial as well. Available research supports the idea that this problem can be managed or alleviated effectively using a multifaceted approach that includes. Preventive education, postural and positioning strategies, proper selection and use of ergonomic equipment and frequent breaks with stretching and postural strengthening techniques. It is important that dentistry incorporate these strategies into practice to facilitate balanced musculoskeletal health that will enable longer, healthier careers; increase productivity; provide safer workplaces; and prevent MSDs.

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