

TABLE OF CONTENTS

| | |
|---|-----------|
| Musculoskeletal Disorders (MSDs) | 1 |
| MSD Hazards | 2 |
| Health Effects | 5 |
| Application of Ergonomics | 10 |
| Working Posture and Techniques | 19 |
| Future Considerations | 22 |
| References | 25 |

Musculoskeletal Disorders (MSDs)

MSDs are injuries and disorders of the musculoskeletal system. The musculoskeletal system includes muscles, tendons, tendon sheaths, nerves, bursa, blood vessels, joints/spinal discs, and ligaments. MSDs may be caused or aggravated by the presence of one or any combination of the following risk factors: repetition, awkward or static postures, high forces, and contact stress. When these factors exist simultaneously, the risk of developing a MSD is significantly increased.

Although some musculoskeletal injuries occur at one specific moment, many more injuries result from repeated strength demands coupled with lack of significant rest periods that together, exceed the tissue tolerance of an individual. Since an injury lowers one's capacity and overall tissue tolerance of that area, returning to pre-injury duties before adequate rehabilitation could result in increased risk of developing a more severe or permanent injury or overusing another body part to compensate for the current injury (Putz-Anderson, 1988).

MSDs and Dental Work

With over 11,000 registered dental hygienists in Canada and about 100,000 in the United States, the American Dental Hygienists' Association predicted a 41% growth rate in new jobs between 1992 and 2005 (Smith, 2002).

Researchers have found symptoms of discomfort for dental workers occurred in the wrists/hands (69.5%), neck (68.5%), upper back (67.4%), low back (56.8%) and shoulders (60.0%). They also found that 93% of those surveyed stated that they had at least one job-related ache, pain, or discomfort in the 12 months prior to the survey (Anton, 2002).

With respect to dental hygienists, Atwood and Michalak (1992) reported that the prevalence of musculoskeletal pain ranged from 63 to 93%, with the low back, neck, shoulder, and hand being the most frequent sites. According to an evaluation from the Bureau of Labor Statistics (2002), dental hygienists ranked first above all occupations in the proportion of cases of carpal tunnel syndrome per 1,000 employees (Anton, 2002).

Conditions can vary from mild recurrent symptoms to severe and incapacitating. Early symptoms of MSDs include pain, swelling, tenderness, numbness, tingling sensation, and loss of strength.

MSD Hazards

Awkward Postures

Posture is a term used for the position of various parts of the body during an activity. For most joints, a good or “neutral” posture means that the joints are being used near the middle of their full range of motion. The further a joint moves towards either end of its range of motion, or the further away from neutral, the more awkward or poor the posture becomes and the more strain is put on the muscles, tendons and ligaments around the joint. For example, when arms are fully outstretched, the elbow and shoulder joints are at the end of their range of motion. If an individual pulls or lifts repeatedly in this position, there is a higher risk of injury (OHSCO, 2007).

The use of awkward postures is perhaps the greatest risk factor for those in the dental field. Researchers have confirmed the presence of awkward postures specifically in the neck, back, shoulders, hand and wrist for dental professionals. Awkward postures are often adopted due to improper seating, improper patient positioning and/or poor work techniques. Common awkward postures in dental practice include elbow and wrist flexion and thumb hyperextension, which have been shown to stress neurovascular structures and ligaments.

The following diagram shows the reduction in strength which occurs as the wrist deviates further away from its neutral posture.

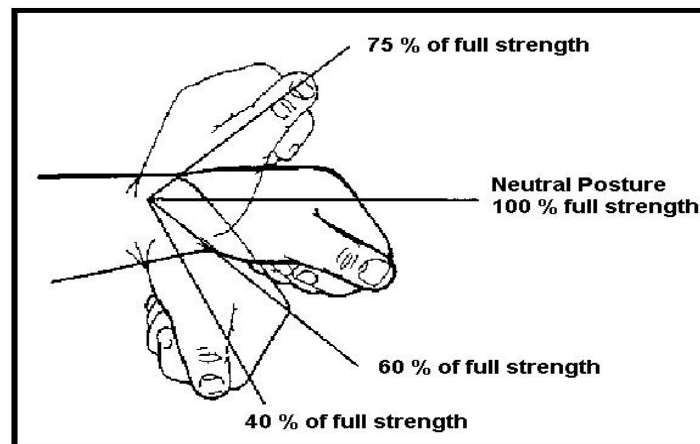


Figure 1: Wrist strength and posture
Source: AgrAbility Project

Static Postures

Static postures are defined by those which are held for a long period of time and may result in fatigue and injury. Oxygen is delivered to the muscles and joints by blood. When a posture is held for a prolonged period of time there is a reduction in blood flow to the tissues. This results in a reduction of nutrient and oxygen supply with lactic acid and other metabolites accumulating, which can

result in pain and tissue damage. Researchers have found that even 30 degrees of forward shoulder flexion or abduction can cause a significant impairment in blood circulation within the shoulder / neck region (Jarvholm, 1989). Furthermore, dental practitioners have been observed statically holding postures requiring greater than 50% of the body's musculature to contract. This results in increased muscular effort which can lead to muscle overload, decreased blood flow and increased pressure on muscles and joints (Park 2009). Static gripping for durations exceeding 20 minutes was also noted during instrumentation tasks within dental practice (Sanders, 1997).

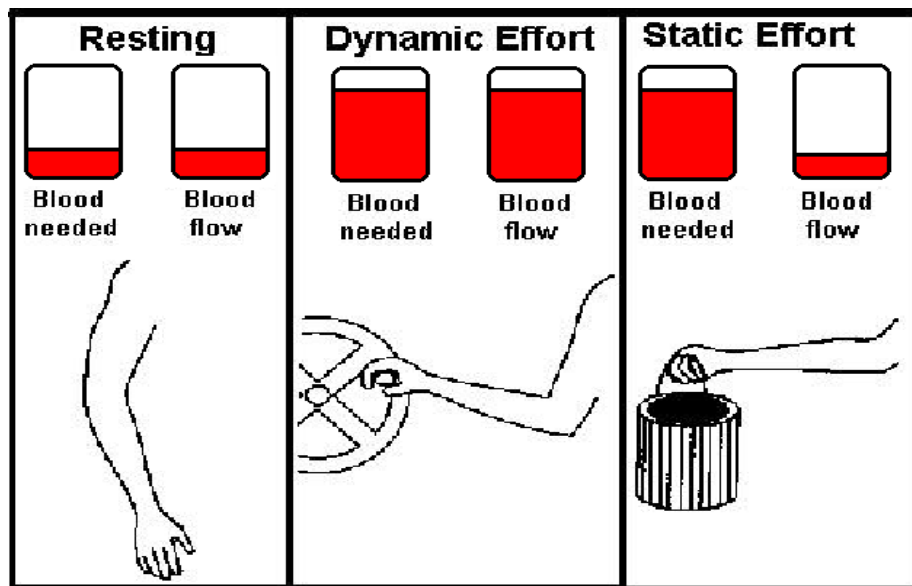


Figure 2: Changes in blood flow to any given muscle
 Source: Nexgen Ergonomics

Force

Force refers to the amount of effort created by the muscles as well as the amount of pressure placed upon a body part. All tasks require workers to use their muscles to exert some level of force, however, when a task requires them to exert a level that is too high for a particular muscle, it can damage the muscle or related tendons or joints and/or other soft tissue (OHSCO, 2007).

An example of a gripping task requiring high force application could be holding small instruments for a prolonged period of time. This task is commonly performed with a pinched grip where the fingers are on one side of the object and the thumb is on the other. This form of gripping is undesirable as it requires a much greater force application than a power grip (object in the palm of the hand). Researchers have suggested that excessive use of a pinch gripping is the greatest contributing risk factor in the development of MSDs among dental hygienists (Sanders, 1997). Additionally, scaling procedures involving both waving and rotary motion power strokes have been classified as the most demanding task required of hygienists (Horstman, 1997).

Repetitive Movements

The risk of developing an MSD increases when same or similar parts of the body are used continuously, with few breaks or chances for rest. Highly repetitive tasks can lead to fatigue, tissue damage, discomfort, and, eventually injury. This can occur even if the level of force is low and the work postures are not awkward (OHSCO, 2007).

During instrumentation, there is a constant alternation between wrist flexion, extension, and forearm rotation. Repetitive gripping is experienced throughout the day in order to write, clean and hold instruments, and expose radiographs. Such high usage of wrist and forearm musculature has been linked to an increased risk of fatigue and overuse (Sanders, 1997).

Repetitive motions are extremely prevalent in clinical practice, particularly when performing scaling, root planning and polishing. Three critical components to consider include:

- **Frequency**
 - refers to how many times an action is repeated
 - examples include: repetitive wrist motions, the number of cleanings performed in a day, the number of instruments gripped by one hand
- **Duration**
 - refers to how long an action is performed
 - examples include: length of time spent holding an instrument, length of time sitting in a static posture, the total length of a work day
- **Recovery time**
 - refers to the time which breaks a repetitive cycle
 - examples include: time between clients, scheduled breaks, time spent stretching

Vibration

Although vibratory tools are used in the dental field research has shown that the daily vibration exposure of dentists is relatively low with respect to the exposure action value (European Union Vibration Directive, 2010). A long work history in dental filling and root treatment as well as high BMI seem to be associated with frequent finger symptoms perceived as vibration-related by dentists.

However, vibration exposure in dentistry may be of concern when one must grip vibratory tools for prolonged periods of time. The reason is that when holding a vibrating tool, muscles begin to tire due to over stimulation. As this occurs, the operator must squeeze harder in order to continue to operate the tool which in turn increases internal force application of the surrounding musculature.

Health Effects

Wrist

The risk factors associated with dental work that most commonly affect the wrists are chronic repetitive movements, awkward and static positions, mechanical stresses to digital nerves such as sustained grasps on instrument handles, extended use of vibratory instruments and inadequate work breaks. The wrist is in constant demand, often sustaining excessive and repeated stresses and strains. The safest position for the wrist is a straight or neutral position. Special care should be used to avoid bending the wrist downwards (flexion) or outwards (ulnar deviation).

Carpal Tunnel Syndrome (CTS)

CTS is one of the most common problems that affect the hand and wrist. CTS occurs when the median nerve, which runs from the forearm into the hand, becomes pressed or squeezed at the wrist. The median nerve controls sensations to the palm side of the thumb and fingers (although not the little finger), as well as impulses to some small muscles in the hand that allow the fingers and thumb to move.

The carpal tunnel is a narrow, rigid passageway of ligament and bones at the base of the hand. It houses the median nerve and tendons. Thickening from irritated tendons or other swelling narrows the tunnel and causes the median nerve to be compressed. The result may be pain, weakness, or numbness in the hand and wrist, radiating up the arm.

Repetitive wrist motions, especially while a pinch pressure is exerted by the fingers, have been linked to an increased incidence in developing CTS (Huntley, 1988).

The exact amount and type of repetitive movements performed during dental work has not yet been accurately quantified by previous studies. However some researchers have highlighted that one of the predictors for the high prevalence of CTS among dental hygienists was their longer clinical period of repetitive movements when work was done on parts of the mouth that were difficult to access and required precise movement and control (Mangharam, 1998).

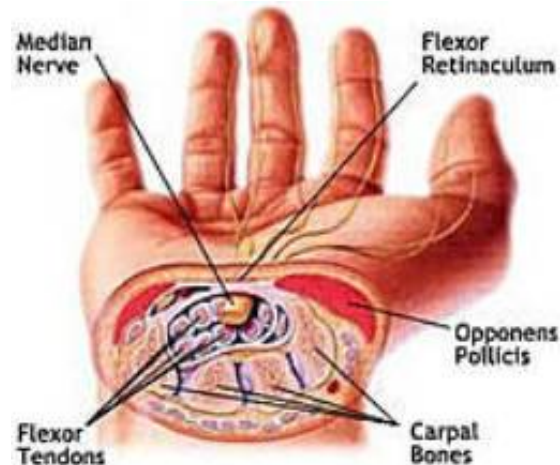


Figure 3: Structures of the carpal tunnel
Source: safecomputingtips.com

Tendonitis of the Wrist

Tendonitis is an inflammation of tendons, which are the structures that attach muscle to bone. Tendonitis of the wrist is accompanied by pain, swelling and inflammation on the thumb side of the wrist, and is made worse with grasping and twisting activities (e.g. polishing and scaling). People with this disorder have often noted an occasional “catching” or snapping when moving their thumb.

Guyon’s Syndrome

Guyon's canal is a space at the wrist between the pisiform bone and the hamate bone through which the ulnar artery and the ulnar nerve travel into the hand. Compression of ulnar nerve occurs in this space at the base of the palm. It is commonly caused by repetitive wrist flexing or excessive pressure on palm/base of hand. It is characterized by pain, weakness, numbness, tingling, burning in the little finger and part of the ring finger.

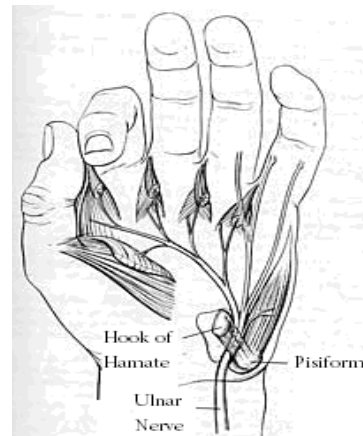


Figure 4: Anatomy of Guyon's Canal
Source: Pittsburgh's Nerve Study

Fingers

Grasping or pinching light objects becomes a problem when the item is held for long periods. The pressure can reduce blood flow and strain tendons, leading to hand symptoms. Repetitive motion, such as prolonged grasping, can lead to tendonitis (inflammation of the tendons).

DeQuervain’s Tenosynovitis

This disorder is characterized by pain and swelling in the thumb and wrist area when grasping, pinching, twisting, and a decreased range of motion of thumb with pain. Possible causes include synovial sheath swelling, thickening of tendons at base of thumb, and repeated trauma or twisting hand/wrist motions.

Trigger Finger

Trigger Finger often results from sustained forceful grips and repetitive motion which irritates the tendon and tendon sheath (tenosynovium). Nodules form in tendon causing warmth, swelling, and tenderness of the tendon. Pain occurs during movement that place tendons in tension. The fingers lock in the “Trigger Position”.



Figure 5: Trigger Finger
Source: Cleveland Clinic

Elbow

The elbow should generally be held at a right angle or ninety degrees. Because blood vessels and nerves supplying the forearm and hand travel along the elbow joint, repeated or prolonged bending can cause compression, leading to forearm and hand symptoms.

Epicondylitis

Injuries at the elbow typically occur at either the inside of the elbow, referred to as Medial Epicondylitis (golfer's elbow), or outside of the elbow, known as Lateral Epicondylitis (tennis elbow). The forearm flexors, used to make a fist, attach at the inside portion of the elbow. Whereas the forearm extensors, used to open the hand, attach at the outside of the elbow.

Cubital Tunnel Syndrome

Cubital Tunnel Syndrome is often caused by prolonged use of the elbow while flexed, resting the elbow on an armrest, or trauma from overuse can compress the ulnar nerve. It is characterized by pain, numbness, tingling and impaired sensation in the little and ring fingers, side and back of hand, loss of fine control, and reduced grip strength.

Shoulders

Rounding the shoulders can compress nerves, arteries, and veins that supply the arm and hand, leading to upper extremity symptoms. Poor thoracic alignment also limits oxygen intake. Slouching forward compresses the chest cavity, preventing the diaphragm muscle from completely filling the lungs with air. When oxygen is diminished, the body experiences fatigue and loss of concentration.

Bursitis

The term bursitis means that the part of the shoulder called the bursa is inflamed. There are many different problems that can lead to symptoms from inflammation of the bursa, one of those being impingement.

Thoracic Outlet Syndrome (TOS)

TOS is a condition resulting from compression of the nerves, arteries, and veins as they pass through from the neck to the arm (thoracic outlet). Possible causes include tight scalenes and pectoralis muscles, extra cervical rib, and prolonged durations of working with elevated elbows. This disorder is characterized by pain in the neck, shoulder, arm or hand, numbness and tingling of fingers, muscle weakness/fatigue, and cold sensation in the arm, hand or fingers.

Rotator Cuff Tear

The rotator cuff (RC) is a group of 4 muscles; supraspinatus, infraspinatus, teres minor and subscapularis. The RC assists with both gross and fine motor control of the arm. RC injury tends to occur where the muscle's tendon attaches to the bone.

Rotator Cuff Tendonitis

This disorder is characterized with pain and stiffness in the shoulder associated with backward and upward arm movements, and weakness of rotator cuff muscles. Possible causes include swelling or tearing of rotator cuff soft tissue, shoulder joint bone spurs/abnormalities, and poor shoulder posture.

Neck

Pain and discomfort are the most common complaints reported in the neck/shoulder region amongst dental professionals. Studies have also shown that female dentists reported neck symptoms 1.4 times more often than male dentists (Mangharam, 1998).

It is common for pain in the arm and hand to stem from problems in the neck. Neck and arm strain can be prevented by keeping the head and neck in proper alignment. The slight inward curve of the neck balances the head on the spine. Holding the head forward disturbs this balance, straining the joints and the muscles of the neck and upper back. This posture also causes compression of the nerves and blood vessels as they exit the neck, leading to symptoms in the arm and hand.

Neck problems generally arise from prolonged static neck flexion and shoulder abduction or flexion, lack of upper-extremity support, and inadequate work breaks. Awkward postures are often adopted to obtain better views of the intraoral cavity, provide a more comfortable position for the patient and to coordinate their position relative to the dentist or assistant.

Myofascial Pain Disorder (MPD)

MPD is characterized by pain and tenderness in the neck, shoulder, arm muscles, and a restricted range of motion. Possible causes include overloaded neck/shoulder muscles.

Cervical Spondylosis

This disorder is characterized by intermittent/chronic neck and shoulder pain or stiffness, headaches, hand and arm pain, numbness, tingling, and clumsiness. Possible causes include age-related spinal disc degeneration leading to nerve compression and spinal cord damage, arthritis, and time spent with the neck in sustained awkward postures.

Back

General Pain

The main risk factors associated with dental work are the sustained awkward postures and poor seating. Most individuals with low back pain do not simply injure their back in one incident but rather gradually over time. Repeated stresses from over the years begin to add up and slowly cause degeneration of various parts of the spine, resulting in low back pain.

Disc Problems

In a seated posture the pressure in the lumbar discs increases by 50% as compared to standing. Additionally, sitting in an unsupported posture can cause twice the amount of stress as compared to standing. During bending (forward flexion) and twisting (rotation) motions of the spine, the pressure on the lumbar discs increases by 200% (Fisk, 1987). This type of pressure on the disc can lead to a bulge or herniation, causing compression on a spinal nerve.

Examples of Disc Problems

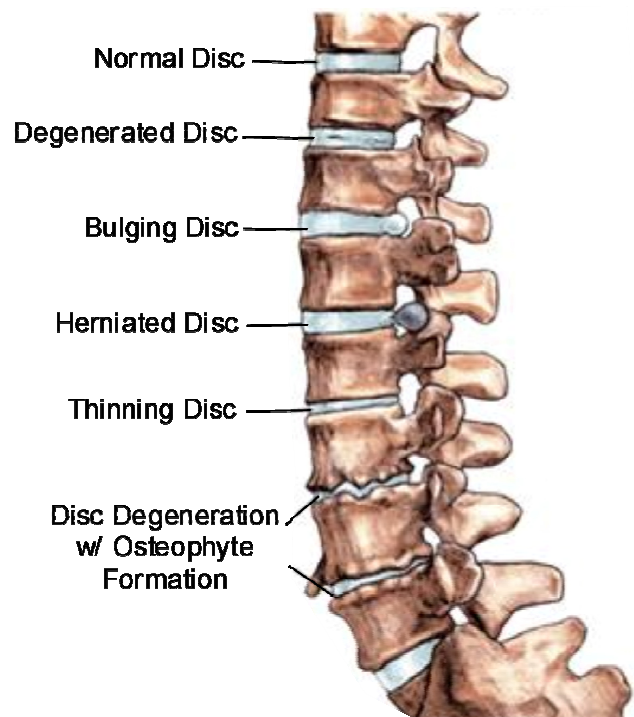


Figure 6: Common disc problems
Source: WebMD

Sciatica

Sciatica is characterized by pain in the lower back or hip radiating to the buttocks and legs, causing leg weakness, numbness, or tingling. It is commonly caused by bulging, prolapsed or herniated discs compressing a spinal nerve root and is worsened with prolonged sitting or excessive bending and lifting.



Application of Ergonomics

Through ergonomic advances made over the years, dental professionals have been able to modify and optimize their working environments. Ergonomic improvements in seating, instrumentation, magnification, lighting, and glove use have offered a proactive measure for ensuring a proper balance between job requirements and worker capabilities.

Seating

Perhaps the most important equipment purchase made by dental professionals, is the seat. Proper seating is a complex subject about which there is much misunderstanding. Research findings indicate that dentists who sit 80 to 100% of the day are at an increased risk of developing low back pain (Mangharam, 1998). Prolonged sitting in a poorly designed chair with inadequate lumbar support or adjustability has been found to be a contributing factor to muscular fatigue and low back pain (Johanning, 1998).

Studies have shown that the seat moves almost every minute throughout a typical treatment session, as the clinician is continually adjusting their positioning to improve visual access and accommodate patient movement. As a result, the support base itself must be capable of sustaining the repeated stress. A seat should be constructed of a rigid cast frame that will not distort with time and use. This rigid base must accommodate five casters to prevent rearward tipping, however the base should not be as wide as that of an office chair. The compact base ensures that the wheels do not interfere with the feet, foot controls, or patient chair (Sanders, 1997). The seat pan should be wide enough to allow for some shifting and movement. Twenty-five percent wider than the total breadth of the buttocks is considered adequate for the majority of people. The front edge of the seat should taper off and away from the legs so as not to impede circulation and nerve supply to the leg.

The seat should also be height adjustable. When the feet are resting flat on the floor the angle between the spine and the thighs should be 90 to 110 degrees. An angle less than 90° flattens the lumbar curve of the spine and an angle greater than 110° gives the feeling like you are slipping off the seat. Variations in footwear (high heeled shoes to flats) should have the clinician altering their seat height day to day depending on what they are wearing. Researchers recommend that a shorter clinician have a seat adjustment range from 16 to 21 inches, while taller individuals have a range of 21 to 26 inches. In an ideal situation, a clinician should be able to function from a height range where their thighs are parallel with the floor and the legs are in fully supported position (Sanders, 1997).

While arm support is a controversial subject, many clinicians and experts feel that they are essential to health and comfort. The capability for highly supportive arms that function through a wide range of motion is an option that most modern dental stools provide. If elbow rests are present, they should be positioned just

below seated elbow height so that when the shoulders are not elevated when using the rests. They should not impede access to the patient while keeping their elbows at the side. Arm support may be fixed in length but should allow rapid height adjustment and full articulation. Some researchers have found the use of elbow rests to reduce upper trapezius muscle load as well as the frequency and range of arm abduction during regular dental tasks (Marchand, 2001).

When selecting a dental stool, ensure it meets the above criteria and allows you to work in a neutral body position. With numerous designs currently available on the market, each chair has its own unique advantages and disadvantages. As a result, it is important to speak with product specialists and try the chair under real working conditions before committing to purchase. The following images show various chair designs currently available on the market. It is recommended that each manufacturer be contacted directly for further information.



Brewer Operator Stool



Posiflex Stool



Kobo Chair

Patient 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 vantage 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, and inability of the clinician to access free movement in the clock positions.

When the patient is properly positioned your shoulders, elbows, and wrists should be in a neutral position, meaning that:

- your upper arms are close to your body
- your elbow / forearm angle is close to 90°
- your wrists are in line with the forearm with no more than 20-30° extension

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 equipment. Although instrument design has come a long way since its beginning, dental professionals often select instruments based on familiarity rather than actual quality or specific properties (Sanders, 1997). The goal of proper instrument selection should be to reduce force exertion while allowing for neutral joint positioning.

The following table summarizes critical areas to consider when selecting new or evaluating existing instrumentation.

| | |
|-------------------------------------|---|
| <p>Handle shape and size</p> | <ul style="list-style-type: none"> • Dental instrument diameter ranges from 5.6 to 11.5 mm. Larger handle diameters reduce hand muscle load and pinch force, although diameters greater than 10 mm (3/8 inch) have been shown to offer no addition advantage (Dong, 2006). • Alternating tools with different diameter sizes allows the user to reduce the duration of prolonged pinch gripping. Sleeves that fit over the handles of mirrors have been shown to reduce grip force (Simmer-Beck, 2006), but may not have the same effect on scaling instruments due to the extra force required when scaling. • “No. 4” handle lessens pinch gripping and can be purchased for most instruments. • A round handle, compared to a hexagon handle will reduce muscle force and compression. |
| <p>Weight</p> | <ul style="list-style-type: none"> • Lightweight instruments (15 g or less) help reduce muscle workload and pinch force (Dong, 2006). |

| | |
|---|--|
| <p>Balance / Maneuverability</p> | <ul style="list-style-type: none"> • The instrument should be equally balanced within the hand so that the tendency to deviate the wrist is reduced. • Balancing an instrument is improved using a third digit rest compared a fourth digit rest since it does not engage the wrist as much while guiding and positioning the hand piece. The second digit (index finger) can detect very fine movements and should be placed close to the operating point. By not using the fourth digit as a stabilizer of the hand piece reduces the number of fingers in the oral cavity, improves the ability to position instruments, and involves as few joint segments as possible thereby improving the degree of control and providing enhanced tactile ability. |
| <p>Ease of operation</p> | <ul style="list-style-type: none"> • The easier it is to operate a tool, the better. Less time is spent searching for buttons, thereby reducing the risk of error. Less time is also spent learning how to use the device. Simple activation is also important, such as using a foot pedal or handle turn to activate the tool as they do not require the operator to hold a button in a sustained pinch grip for extended periods of time. |
| <p>Sharpness</p> | <ul style="list-style-type: none"> • As a tool becomes dull, additional force is required to perform tasks. As a result, it is important to maintain sharpness of the instruments. |
| <p>Texture</p> | <ul style="list-style-type: none"> • Knurled handles such as diamond-shaped or criss-cross patterns serve to reduce pinch grip force due to an increase in tactile sensation as a result of the knurl. |

Additional tips for instrument selection:

- Hollow or resin handles are preferred
- Round, textured/grooves (knurled), or compressible handles are preferred
- Colour-coding may make instrument identification easier
- Carbon steel construction (for instruments with sharp edges) is preferred

Dental Hand Pieces

When selecting hand pieces, look for:

- Lightweight, balanced models (cordless preferred)
- Sufficient power
- Built-in light sources
- Angled vs. straight-shank
- Pliable, lightweight hoses (extra length adds weight)
- Swivel mechanisms
- Easy activation

Equipment Layout

Dental equipment should be located in a manner which allows you to maintain a neutral working posture. It should require minimum adjustment and effort to access so as to reduce postural deviation while working. 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. Frequently used items such as the syringe, hand piece, saliva ejector and high volume evacuator should be positioned so they are within a normal horizontal reach which is the arc created while sweeping the forearm when the upper arm is held at the side. Items that are used less frequently used should be placed within the maximal horizontal reach which created when the arm is fully extended. The following image shows the difference between a normal and maximum work area.

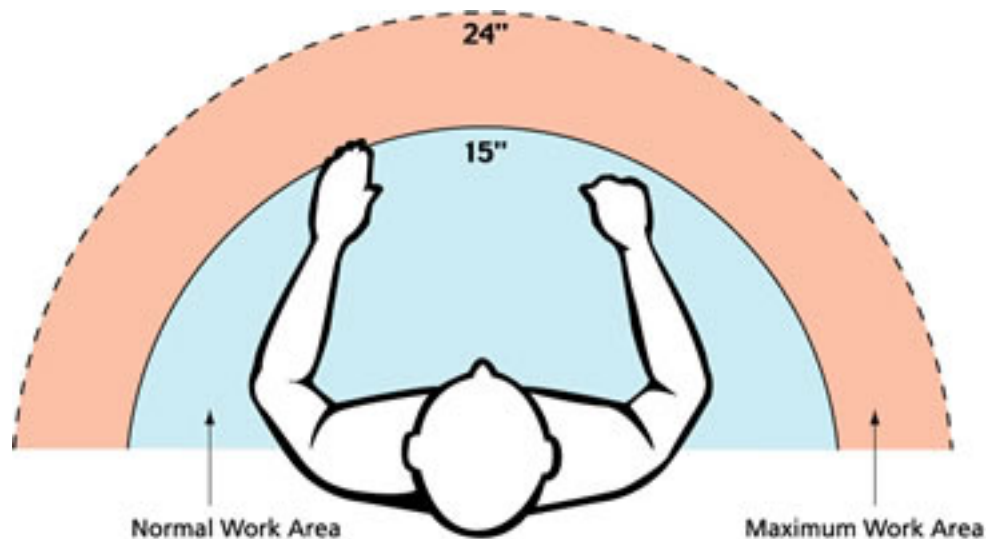


Figure 7: Preferred working area of the hands
Source: Esslab



Ultrasonic Tools

While ultrasonic tools can serve to reduce prolonged pinch gripping they do expose the clinician to hand-arm vibration. Research has been controversial regarding the relationship between the use of ultrasonic scalers and the development of musculoskeletal problems. While some studies indicate that prolonged use of this equipment can be hazardous due to the negative effects associated with vibration, other researchers suggest that its use is preferable to the heavy hand forces experienced during manual scaling. As result, educators suggest using ultrasonics for heavy calculus build-up, but limiting the overall usage of this vibrating tool (Sanders, 1997).

Cord Management

The added weight of cords can often influence the level of muscle fatigue experienced by a clinician. Additionally, coiled hoses can cause the hands and wrists to do more work if the coils have too much resistance to deformation. As a result many hygienists tend to wrap the cord around their arm or try to pinch it between their ring finger and smallest finger in order to support the weight. Other individuals use a variety of creative methods to counterbalance cord weight. While none of these techniques have been scientifically tested basic recommendations do exist to assist with cord management (UBC, 2008).

Firstly, it is recommended that retractable or coiled hoses be avoided and replaced with a pliable hose which consists of a swivel mechanism in the barrel. Newer 360 degree swivel cords also provide increased flexibility for managing the cord. Positioning heavier cords over the arm or across an armrest can also be beneficial for reducing muscle strain (UBC, 2008).

Syringes and Dispensers

When selecting look for:

- Adequate lumen size
- Ease in cleaning
- Textured/grooved handles
- Knurled handles (no finger cut-outs)
- Easy activation and placement

Mouth Mirror

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

If you are unable to visualize the operating site directly while maintaining a neutral posture, you must use a mirror to prevent awkward body positioning, specifically of the neck and back. Intraoral mirrors can also be used to reflect additional light on the operating site even when a direct view is possible. 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 (University of British Columbia (UBC, 2008).

With the respect to retraction, the mirror's face (or back of the face) may be used to retract the tongue or cheek however its handle should never be used. The handle is poorly designed for comfortable retraction (both for the patient and for the clinician) and could potentially harm soft tissues within the oral cavity. If static retraction is required, it is recommended that a proper retraction tool be used, such as those commonly used in oral surgery practices (UBC, 2008).

Magnification

In an attempt to clearly see the operating field some clinicians may be tempted to compromise their working posture by bending closer to the patient. Deviation away from a neutral working posture in order to magnify or clarify the view of the operating field is both undesirable and unnecessary. Through the use of various magnification systems, dental professionals are able to increase their working distance and assume more of an upright body posture. As a result, surgical magnification can play a significant role in reducing awkward working postures, specifically forward neck and trunk flexion (Rucker, 1998).

Today there are several distinct categories of surgical magnifiers available on the market. Stationary or fixed microscopes are generally wall or ceiling mounted and used for high magnification (5x to 20x). While such magnification levels serve a specific purpose they are rarely used in general clinical practice. It is important to remember that the more the magnification power the smaller the field of view, the smaller the depth of field and the less light available for vision. Reducing these components of the magnification system often leads to a compromise in the clinician's working posture as they typically begin to lean forward to see the operating area. As a result *less magnification is typically recommended* for general clinical practice (UBC, 2008).

Surgical telescopes comprising of multi-lens systems offer lower magnification levels (2x to 3x) which are preferred due to their portability and ease of use. These devices are commonly referred to as "surgical loupes" and can be mounted to a headband or onto the operator's glasses. Through the use of such magnification systems dental practitioners are able to maintain a neutral working posture while increasing their visual acuity, level of motor control, and diagnostic ability (UBC, 2008).

BUYER BEWARE

Purchasing the right magnification system may seem like a daunting task as numerous manufacturers exist on the market, all offering multiple product lines. However, being well informed and speaking to knowledgeable product representatives is the best way to ensure that the product you select meets all of your needs and most importantly allows you to work in a neutral posture.

When selecting surgical telescopes many critical features and personal preferences should be taken into consideration. The following table provides a recommended guideline of the components which should be further examined and discussed with a product specialist during your selection process.

Components of a Magnification System

| Critical Features | Personal Preferences |
|--|--|
| <ul style="list-style-type: none"> • Optical declination angle • Coaxial alignment • Working distance • Depth of field | <ul style="list-style-type: none"> • Power of magnification • Size of the field of view • Size of magnification scotoma • Weight of telescopes • Distribution of weight • Adjustability of system • Infection control |

Lighting

Light positioning is a critical factor affecting your posture during clinical operation. The goal of proper lighting is to produce even, shadow-free, colour-corrected illumination concentrated on the operating field. This not only serves to increase visibility but can also reduce awkward working postures. For optimal illumination the light-line must be as close to the sight-line as possible. The greater the deviation of the light-line from the sight-line the greater shadowing (UBC, 2008).

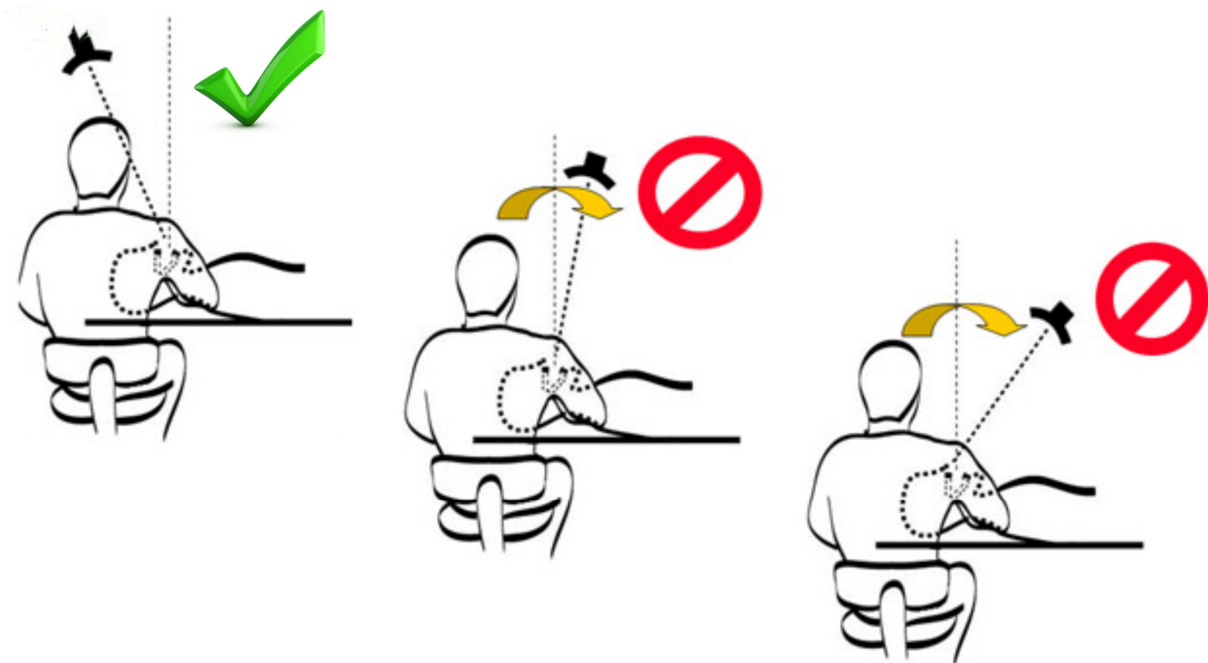


Figure 8: Optimal overhead light positioning
Source: UBC, 2008

Typically, a single light source can provide sufficient unshadowed viewing for a supine patient. For both mandibular and maxillary treatment, the light source should be directly above and slightly behind the patient's oral cavity. This position will insure that the light-line just barely clears your head throughout a full range of o'clock positions. Once the patient has been properly situated, the light source can be positioned as far above the clinician's head so as to just allow it to be reached. This ensures that it can still be repositioned if needed however it is out of the way from being accidentally moved.

Gloves

Gloves are commonly worn due to universal precautions. Gloves must be of proper size, lightweight, and pliable. Poor fitting gloves can cause pain in the hands, particularly at the base of the thumb. This is often due to compression of the tissues when gloves are either too small or too loose as "bunching" occurs. When used for extended periods of time, gloves must be pulled into a working position, which may compress the back of the hand, strain muscles at the base of the thumb, and reduce blood flow to the hand.

Properly fitted gloves should fit hands and fingers snugly, should not feel tight across the wrists and be hand-specific (right vs left-hand design). Ambidextrous (non-hand specific) gloves are molded with the hand in a flat (neutral) position, restrict thumb opposition, and actually exert one third more force than hand-specific gloves across the palmar region of hand. While ambidextrous gloves can be used for brief examinations, hand-specific gloves are recommended for most dental tasks.

An additional factor in proper glove selection is material. While latex gloves have been known for creating the most natural fit, sensitivity or allergies have created an issue for some clinicians and patients. Fortunately, alternative glove materials, such as vinyl, are available, however they can result in poor fit. A more recent alternative has been the use of chloroprene gloves which provide a very high puncture resistance and have been shown to be more flexible than vinyl (Guignon, 2001).

Compressed Air

- Improves visibility of the field of operation during instrumentation
- Permits easier recognition of location and material of restorations
- Allows easier identification of decalcification
- Allows easier identification of supragingival deposits (e.g. calculus appears chalky and contrasts to tooth colour)
- Deflects the free gingival margin to allow visual sighting of subgingival deposits (e.g. calculus)

Working Posture and Techniques

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 (UBC, 2008).

It is important to ensure that the clinician's access to the oral cavity is truly unimpeded. You should be able to move freely with your legs beneath the patient's head and headrest to avoid twisting or forward bending of the torso. If this is not possible, you may be forced to spread your thighs and knees apart and lean forward or twist with the knees together on one side. Either of these positions compromises a neutral working posture and should be avoided (UBC, 2008). As a result, most clinicians attempt to use a wide range of positions around the patient's head, often referred to as the "o'clock positions".



Figure 9: Clock positions
Source: UBC, 2008

For right-handed clinicians, working in the range from 7 to 9 o'clock is commonly associated with twisting of the trunk and neck as well as working with an elevated elbow posture in order to gain access. The mirror image (3 to 5 o'clock) is equally problematic for left-handed clinicians. In an attempt to reduce such postural deviations a conservative range from 10 o'clock to approximately 12:30 is preferred and shown below (UBC, 2008).



Figure 10: Preferred working ranges
Source: UBC, 2008

Working Technique

Within the scientific community there is a great deal of discussion surrounding current working techniques used by dental professionals. Researchers have found that “currently accepted techniques” can increase the risk MSDs as they employ same or similar patterns of muscle activity. In doing so, these techniques can increase the rate of muscle fatigue and lead to the development of a MSD.

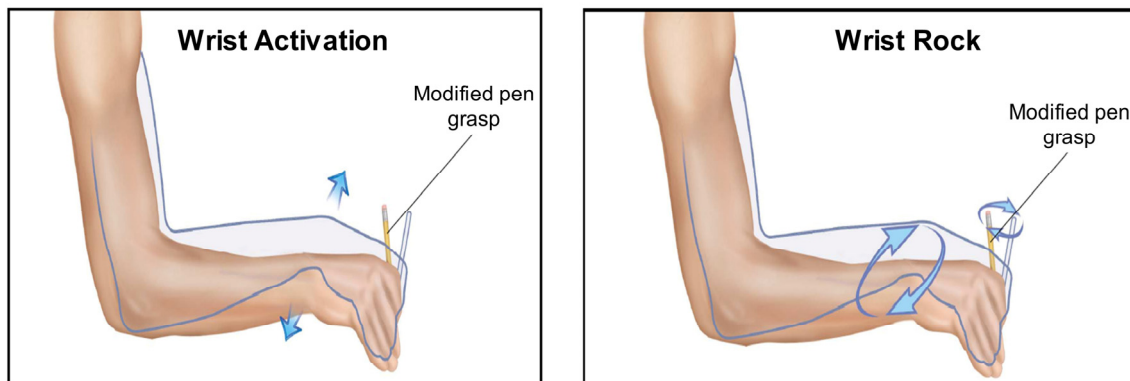


Figure 11: Wrist motions in the Currently Accepted Techniques
Source: Meador, 1997

More recently, discussion has shifted towards the use of a “biocentric technique” which 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, coupled with the wrist activation and wrist rock which are common to the currently accepted technique. Using this technique allows the clinician to maintain a neutral upper extremity position (shoulders level, upper arm vertical, and forearm horizontal) while still offering options for accommodating patients' anatomical variations. Researchers believe the biocentric technique reduces muscular fatigue by varying task performance (Meador, 1997).

Biocentric Technique #1

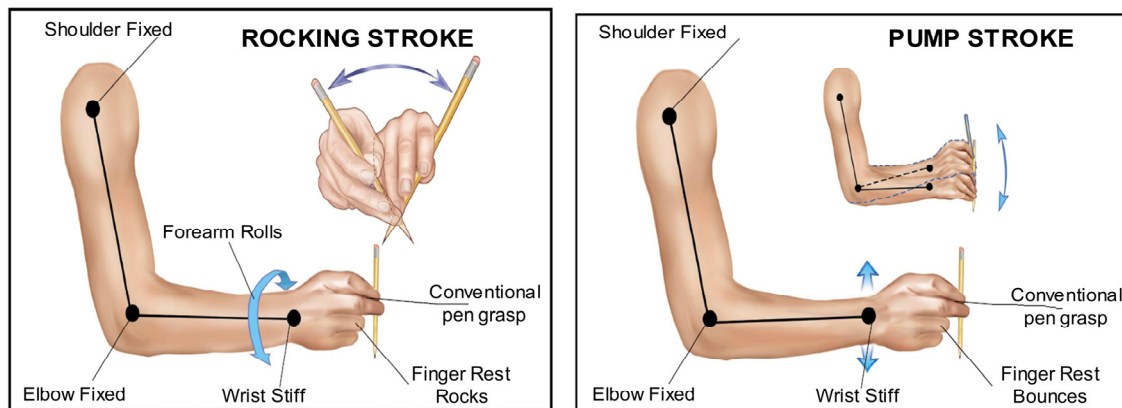


Figure 12: Arm and hand positions in the Biocentric Technique #1
Source: Meador, 1997

Biocentric Technique #2

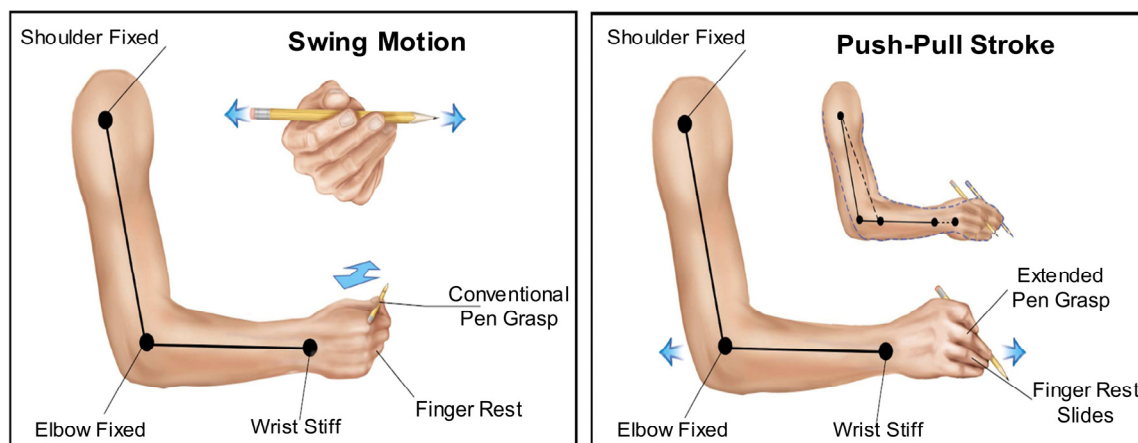


Figure 13: Arm and hand positions in the Biocentric Technique #2
Source: Meador, 1997

Additional tips for improving technique include:

- Alternate grip pressure and techniques used to grip items
- Use “strokes” controlled by larger muscle groups
- Try to maintain joint neutrality

Finger Rests

In addition to increasing hand stabilization, the use of 2-finger rests has shown musculoskeletal advantages when performing scaling procedures. When researchers examined three different finger positions (no rest, 1-finger rest, and 2-finger rests) they found significant reductions in thumb pinch forces and muscle activity when using rests. More specifically, 2-finger rests always produced these reductions, as compared to not using any finger rests, while one finger rest reduced thumb pinch force and muscle activity most of the time (Dong, 2005).

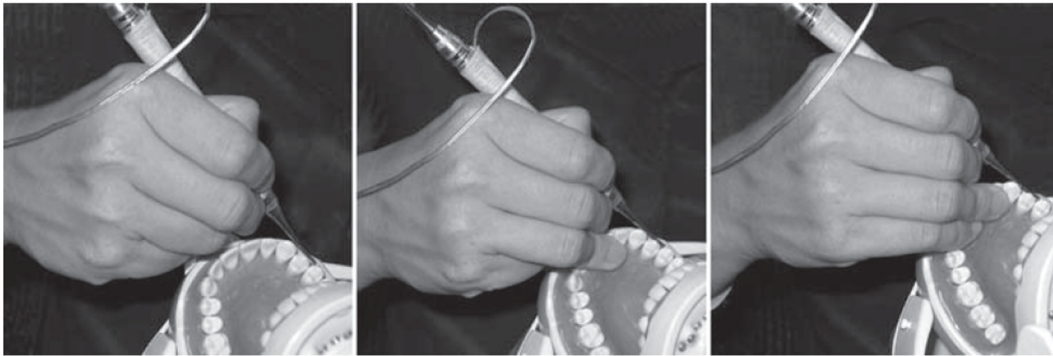


Figure 14: Scaling task performed with three different finger positions
Source: Dong, 2005

As a general rule, the greater the force applied during a task, the greater the requirement for hand stability. Through the use of finger rests, dental practitioners can increase stability while also reducing muscular loading. The closer one can position their finger rest to the target area, the greater the level of micro-control will be achieved.

Future Considerations

Every dental care facility has an opportunity for ergonomic improvement. While employers should always be seeking ways to modify and optimize their workplace to reduce the likelihood of injury, dental professionals need to pay attention to body symptoms in order to make changes that will prevent long-term problems. As a result, ergonomics should be a continuous and proactive measure for ensuring the proper fit between people and their working environment.

The following section provides additional considerations which can be adopted by dental professionals to further reduce their likelihood of developing long-term musculoskeletal problems.

Scheduling

Modifying one's work schedule has been suggested as an effective preventive measure for providing sufficient recovery time and avoiding muscular fatigue.

Recommendations when scheduling include:

- Incorporate brief "stretch break" periods between patients
- Develop a patient difficulty rating scale to ensure difficult treatment sessions are not performed consecutively
- Increase treatment time for more difficult patients
- Alternate heavy and light calculus patients throughout the day
- Alternate procedures performed throughout the day
- Shorten patient's recall interval

Ambidexterity

The majority of people prefer the use of their dominant hand when performing manual operations. While this can improve efficiency, it can also result in muscular overload of the dominant hand/arm. It is recommended that individuals attempt to alternate hands throughout the workday, whenever possible. Although this may not be practical for certain precision tasks, it is possible to alternate hands when performing accessory tasks, such as reaching for tools or supplies.

Stretching

Frequent stretch breaks can prevent detrimental physiological changes that can develop while working in static or awkward postures. In an attempt to prevent injury from occurring to muscles and other tissues, dental professionals should allow for rest periods to replenish and nourish stressed structures. If breaks are too far apart, the rate of damage could exceed the rate of repair and eventually lead to the breakdown of tissue.

Stretching can serve to:

- increase blood flow to muscles
- increase the production of joint synovial fluid
- reduce the formation of trigger points
- maintain normal joint range of motion
- increase nutrient supply to vertebral disks
- create a relaxation response in the central nervous system
- warm up the muscle before beginning to work
- identify tight structures that may be predisposed to injury



Alternating postures during work provides a change from one's habitual position and prevents muscular fatigue. Stretches should be performed for the entire body, focusing on movement patterns that are opposite to the habitual positions experienced during work. Researchers suggest that dental professionals try to 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 (Sanders, 1997).

Points to Remember:

- Perform a variety of stretches throughout the workday
- Stretching should be gentle and gradual
- Do not stretch a muscle to the point of pain
- Stretches can be held up to 10 seconds and repeat 3-5 times
- Breathe normally while stretching
- If you suffer from a musculoskeletal condition consult a Physician before attempting new exercises which you are unfamiliar with

Additional information on stretching, including sample stretches and exercises can be found in OHCOW's **Preventative Maintenance – The Importance of Stretching At Work Facts Sheet**.

Acknowledgments

OHCOW wishes to acknowledge and thank Dr. Lance Rucker from the University of British Columbia - Faculty of Dentistry for his feedback and assistance in developing this document.



References

American Dental Association. 2004. An Introduction to Ergonomics: Risk Factors, MSDs, Approaches and Interventions.

Anton D, Rosecrance J, Merlino L, Cook T. 2002. Prevalence of musculoskeletal symptoms and carpal tunnel syndrome among dental hygienists. *American Journal of Industrial Medicine*. Sep; 42(3):248-57.

AgrAbility Project. 2002. What to look for when selecting or modifying hand tools to provide a better fit with the user. Available online:
http://uwadmnweb.uwyo.edu/agrability/Fact_Sheets/What_to_Look_for_in_Hand_Tools.pdf

Atwood, M.J., & Michalak, C. (1992). The occurrence of cumulative trauma disorders in dental hygienists. *Work* 2(4), 17-31.

Belenky MM. Human-Centered Ergonomics: Proprioceptive pathway to occupational health and peak performance in dental practice. in: *Ergonomics and the Dental care worker*. Denise Murphy Ed. American Public Health Society. Washington, 1998.

Blaes, J, A DDS. 2002. A Dental Office for the 3rd Millennium, *Dental Economics*. June pp 34-36.

Cleveland Clinic. 2010. Trigger Finger and DeQuervains Disease. Available online:
http://my.clevelandclinic.org/disorders/trigger_finger/hic_trigger_finger_and_dequervains_disease.aspx

Dimensions Interactive. 2011. Posture Perfect. Available online:
<http://www.dimensionsofdentalhygiene.com/ddhright.aspx?id=518&terms=ergonomics>

Dong H, Barr A, Loomer P, Rempel D. 2005. The effects of finger rest positions on hand muscle load and pinch force in simulated dental hygiene work. *Journal of Dental Education*. Apr;69(4):453-60.

Dong H, Barr A, Loomer P, Laroche C, Young E, Rempel D. 2006. The effects of periodontal instrument handle design on hand muscle load and pinch force. *Journal of American Dental Association*. Aug: 137(8):1123-30.

Dong H, Loomer P, Barr A, Laroche C, Young E, Rempel D. 2007. The effect of tool handle shape on hand muscle load and pinch force in a simulated dental scaling task. *Applied Ergonomics*. Sep;38(5):525-31.

Dougherty, M. (2001) *Ergonomic Principles in the Dental Setting*. Thomson Healthcare/Dental Products Report.

Esslab. 2010. Best Practices for Workstation Organization. Available online:
www.esslab.com/Vistalab/ergonomics5.htm

European Union Vibration Directive. 2010. Available online: www.euvibrationdirective.net

Fisk J. W. (1987). *Your Painful Neck & Back*. London, Arrow.

Fredekind, R & Cuny, E. (1998). Instruments Used in Dentistry. IN: Murphy, D.C. (Editor), (1998). *Ergonomics and the Dental Care Worker*. Washington, DC. American Public Health Association.

Guignon, A.N. (May 2001). Comfort Zone: at your fingertips. *Journal of Dental Economics*.

Horstman, S.W., Horstman, B.C., & Horstman, F.S. (1997). Ergonomic Risk Factors Associated with the Practice of Dental Hygiene: a preliminary study. *Journal of Professional Safety*, 42(4), 49-53.

Huntley, D.E., & Shannon, S.A. (1988). Carpal Tunnel Syndrome: a review of the literature. *Journal of Dental Hygiene*, 316-320.

Jarvholm, U., Palmerud, G., Herberts, P., Hogfors, C., & Kadefors, R. (1989). Intramuscular pressure and electromyography in the supraspinatus muscle at shoulder abduction. *Journal of Clinical Orthopaedics*, (245), 102-109.

Johanning, E., & Bruder, R. (1998). Low Back Disorders and Dentistry: stress factors and ergonomic intervention. IN: Murphy, D.C. (Editor), (1998). *Ergonomics and the Dental Care Worker*. Washington, DC: American Public Health Association.

Mangharam, J., & McGlothan, J.D. (1998). Ergonomics and Dentistry: A literature review. IN: Murphy, D.C. (Editor), (1998). *Ergonomics and the Dental Care Worker*. Washington, DC: American Public Health Association.

Meador, H. 1997. The Impact of the Biocentric Technique on Pain, Productivity, and Attitude of Dental Hygienists. *Practical Hygiene*. January-February: 25-30.

Medical Multimedia Group. 2010. Carpal Tunnel Syndrome. Available online: <http://orthopedics.about.com/cs/carpaltunnel/a/carpaltunnel.htm>

Michalak-Turcotte C, Atwood-Sanders M. 2000. Ergonomic strategies for the dental hygienist-part II. *Practical Hygiene*. May/June:35-38.

Nexgen Ergonomics. 2010. Available online: www.nexgenergo.com/ergocenter/trends/trends2.html

Nield-Gehrig JS. *Fundamentals of Periodontal Instrumentation and Advanced Root Instrumentation*, 6th Edition. Lippincott Williams and Wilkins. Philadelphia. 2008.

Occupational Health and Safety Council of Ontario (OHSCO). 2007. Part 1:MSD Prevention Guideline for Ontario.

Park, J. 2009. Ergonomics For Dental Hygienists. Available online: www.prospinerehab.com

Pollack R. 1999. The Ergo Factor: The Most Common Equipment and Design Flaws and How to Avoid Them. *Dentistry Today* February, 112-121.

Putz-Anderson, V. (1988). Cumulative trauma disorders. A manual for musculoskeletal diseases of the upper limbs. Pennsylvania: Taylor and Francis.

Rucker, L.M. (1998). Surgical Magnification: posture maker or posture breaker? IN: Murphy, D.C. (Editor), (1998). *Ergonomics and the Dental Care Worker*. Washington, DC: American Public Health Association.

Rucker LM, Boyd MA. 1998. Optimizing dental operator working environments. In: Murphy DC, ed. *Ergonomics and the dental care worker*. Washington, DC: American Public Health Association, 301-18.

Safe Computing Tips. 2011. Carpal Tunnel Syndrome. Available Online: www.safecomputingtips.com/carpal-tunnel-syndrome.html

Sanders, MJ & Turcotte, CA. (1997). Ergonomic strategies for dental professionals. *Work* 8, 55-72.

Simmer-Beck M, Bray KK, Branson B, Glaros A, Weeks J. 2006. Comparison of muscle activity associated with structural differences in dental hygiene mirrors. *Journal of Dental Hygiene*. Winter;80(1):8.

Smith CA, Sommerich CM, Mirka GA, George MC. 2002. An investigation of ergonomic interventions in dental hygiene work. *Applied Ergonomics*. Mar;33(2):175-84.

Sunell, S. & Rucker, L. 2003. Ergonomic Risk Factors Associated with Clinical Dental Hygiene Practice. *Probe*. 37, (4):159-166.

Tatro, D. 1997. Ergonomics for the Dental Hygienist. *Practical Hygiene*. Jan-Feb: 35-39.

University of British Columbia. (2008). *Dental Clinical Ergonomics: study module*. Available Online: www.dentistry.ubc.ca/ergo/

Werner RA, Franzblau A, Gell N, Hamann C, Rodgers PA, Caruso TJ, Perry F, Lamb C, Beaver S, Hinkamp D, Eklund K, Klausner CP. 2005. Prevalence of upper extremity symptoms and disorders among dental and dental hygiene students. *Journal of California Dental Association*. Feb;33(2):123-31.

For further assistance contact the

Occupational Health Clinic for Ontario Workers Inc.

TOLL FREE: 1-877-817-0336

www.ohcow.on.ca

HAMILTON

848 Main Street East
Hamilton, ON, L8M 1L9
Tel: (905) 549-2552
Fax: (905) 549-7993
E-mail: hamilton@ohcow.on.ca

SARNIA-LAMBTON

171 Kendall Street
Point Edward, ON, N7V 4G6
Tel: (519) 337-4627
Fax: (519) 337-9442
E-mail: sarnia@ohcow.on.ca

SUDBURY

84 Cedar Street, 2nd Floor
Sudbury, ON, P3E 1A5
Tel: (705) 523-2330
Fax: (705) 523-2606
E-mail: sudbury@ohcow.on.ca

THUNDER BAY

1151 Barton Street, Suite 103B
Thunder Bay, ON, P7B 5N3
Tel: (807) 623-3566
Fax: (807) 622-5847
E-mail: thunderbay@ohcow.on.ca

TORONTO

970 Lawrence Ave. West, Suite 110
Toronto, ON, M6A 3B6
Tel: (416) 449-0009
Fax: (416) 449-7772
E-mail: toronto@ohcow.on.ca

WINDSOR

3129 Marentette Avenue, Unit #1
Windsor, ON, N8X 4G1
Tel: (519) 973-4800
Fax: (519) 973-1906
E-mail: windsor@ohcow.on.ca

PROVINCIAL OFFICE

15 Gervais Drive, Suite 601
Don Mills, ON, M3C 1Y8
Toll Free: 1-877-817-0336
Fax: (416) 443-9132
E-mail: info@ohcow.on.ca

EVERY EFFORT HAS BEEN MADE TO ENSURE THE ACCURACY OF THE INFORMATION IN THIS WORKBOOK. OHCOW ASSUMES NO RESPONSIBILITY FOR HOW THIS INFORMATION IS USED.

