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Preventing musculoskeletal disorders in clinical dentistry

Strategies to address the mechanisms leading to musculoskeletal disorders

BETHANY VALACHI, M.S., P.T., C.E.A.S.; KEITH VALACHI, D.D.S.

Second in a two-part series on the musculoskeletal health of dental professionals

ABSTRACT

Background. The authors reviewed studies to identify methods for dental operators to use to prevent the development of musculoskeletal disorders, or MSDs.

Types of Studies Reviewed. The authors reviewed studies that related to the prevention of MSDs among dental operators. Some studies investigated the relationship between the biomechanics of seated working postures and physiological damage or pain. Other studies suggested that repeated unidirectional twisting of the trunk can lead to low back pain, while yet other studies examined the detrimental effects of working in one position for prolonged periods. Additional studies confirmed the roles that operators' flexibility and core strength can play in balanced musculoskeletal health and the need for operators to know how to properly adjust ergonomic equipment.

Results. This review indicates that strategies to prevent the multifactorial problem of dental operators' developing MSDs exist. These strategies address deficiencies in operator position, posture, flexibility, strength and ergonomics. Education and additional research are needed to promote an understanding of the complexity of the problem and to address the problem's multifactorial nature.

Clinical Implications. A comprehensive approach to address the problem of MSDs in dentistry represents a paradigm shift in how operators work. New educational models that incorporate a multifactorial approach can be developed to help dental operators manage and prevent MSDs effectively.

Dental operators often cannot avoid prolonged static postures, or PSPs. Even in optimal seated postures, more than one-half of the body's muscles are contracted statically, and there is little movement of the vertebral joints. This may result in damaging physiological changes (microchanges) that can lead to back, neck or shoulder pain or musculoskeletal disorders, or MSDs (macrochanges).[1]

In optimal seated postures, more than one-half of the body's muscles are contracted statically.

In this article, we provide a brief review of spinal anatomy and the biomechanics of sitting postures. This will provide a clearer understanding of how damaging physiological changes occur and enable operators to apply prevention strategies both in and out of the operatory.

THE NATURAL SPINAL CURVES

In standing postures, the spine has four natural curves when viewed from the side: cervical lordosis, thoracic kyphosis, lumbar lordosis and sacral kyphosis (Figure 1).[2] The curves are interdependent; a change in one curve will result in a change in the curve above or below it.[3] Since the sacral curve is composed of five fused vertebrae, its movement is extremely limited. However, the remaining curves—especially the lumbar and cervical curves—are more mobile and can be influenced more easily. When the curves of the spine are present and balanced against the center of gravity, the spine is supported mostly by the

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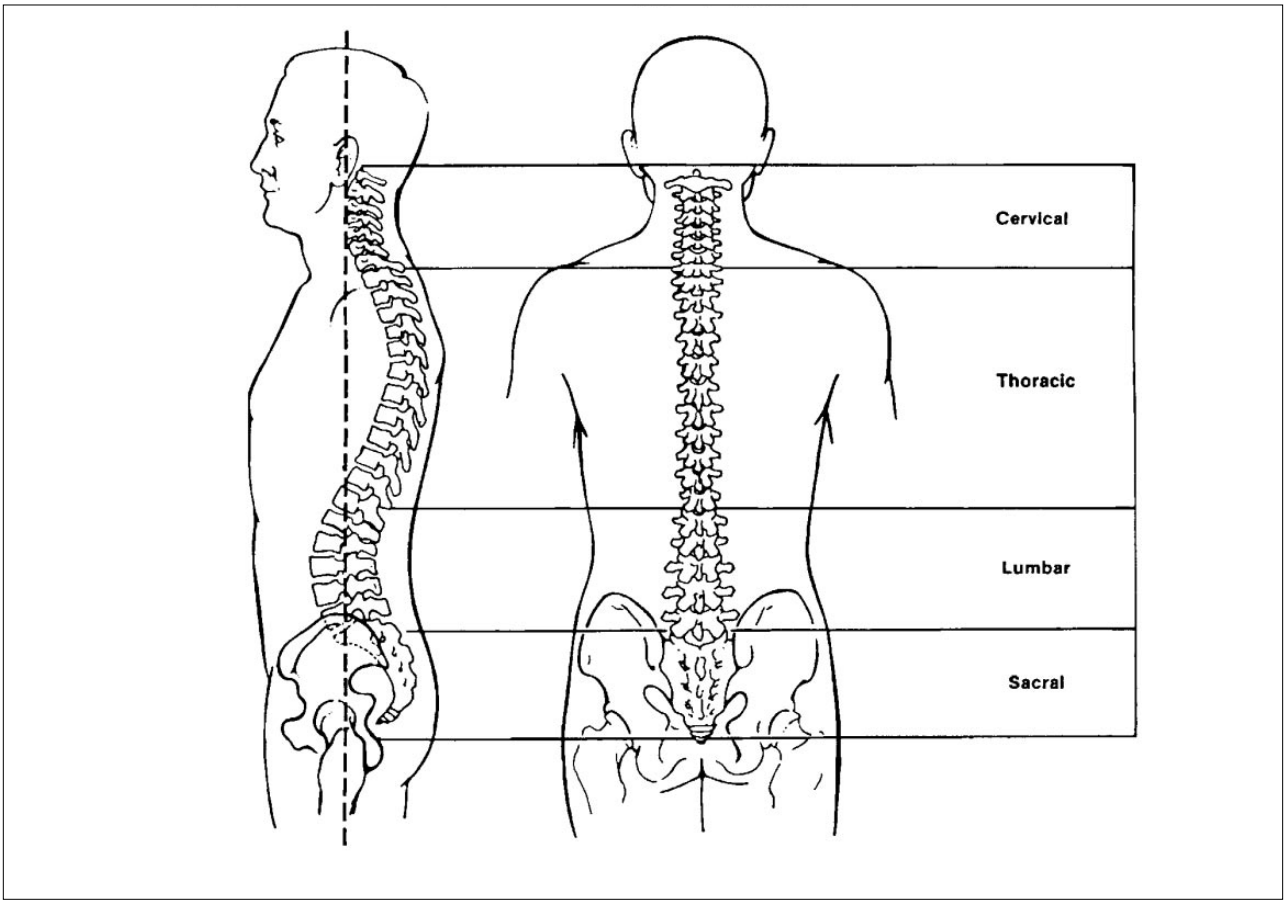

Figure 1. The four primary curves of the spine: cervical lordosis, thoracic kyphosis, lumbar lordosis and sacral kyphosis. Adapted with permission of the publisher from Saunders and Saunders.[2]

bony structures of the vertebrae resting on top of one another. When these curves become either exaggerated or flattened, the spine increasingly depends on muscles, ligaments and soft tissue to maintain erect.

When sitting unsupported—a frequent posture in dentistry—the lumbar lordosis flattens (Figure 2). The bony infrastructure provides little support to the spine, which now is hanging on the muscles, ligaments and connective tissue at the back of the spine, causing tension in these structures. Ischemia can ensue, leading to low back strain and trigger points. This flattening of the lumbar curve also causes the nucleus in the spinal disk to migrate posteriorly toward the spinal cord. Over time, the posterior wall of the disk becomes weak, and disk herniation can occur. Therefore, operators need to know about strategies they can use to maintain the essential lumbar lordosis whenever possible.

Maintaining the cervical lordosis in the proper position is equally important. Forward-head postures are common among dentists, due to years of poor posture involving holding the neck and head in an unbalanced forward position to gain better visibility during treatment (Figure 2). In this posture, the vertebrae no longer can support the spine properly, and the muscles of the cervical and upper thoracic spine must contract constantly to support the weight of the head in the forward posture.[4] This can result in a pain pattern, which often is referred to as tension neck syndrome. This syndrome can cause headaches and chronic pain in the neck, shoulders and interscapular muscles, and it occasionally can radiate pain into the arms. Sustained contraction of cervical muscles also causes weakening of the spinal disks, with possible disk degeneration or herniation.[5] Therefore, frequent relaxing and stretching of the neck muscles, strengthening of the deep postural cervical muscles and preservation of the cervical lordosis in proper posture (ear over the shoulder) with all activities, including sleeping and driving, is essential for optimal muscu-

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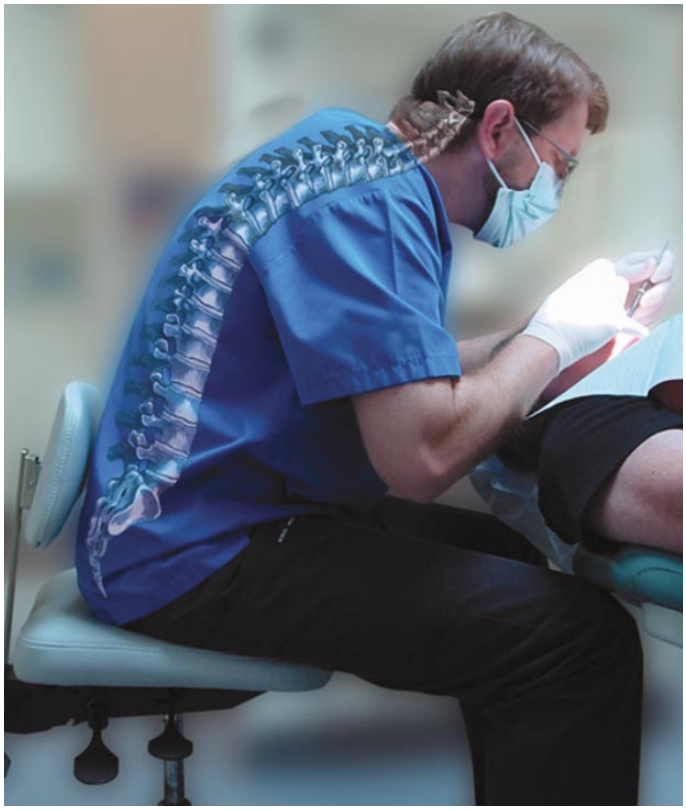

Figure 2. The effects of poor posture on the curves of the spine: flattened lumbar lordosis and a forward-head position.

loskeletal health of the neck.

A forward-head posture also can lead to muscle imbalances,[1] contributing to a rounded shoulder posture. This posture can predispose the operator to impingement of the supraspinous tendon in the shoulder (rotator cuff impingement) when reaching for items. Additionally, static posture of the arms in an elevated or abducted state of more than 30 degrees impedes the blood flow to the supraspinous muscle and tendon.[6,7] Prolonged arm abduction also can lead to trapezius myalgia—chronic pain and trigger points in the upper trapezius muscle.

To effectively prevent injuries in dentistry, prevention strategies and ergonomic techniques must address these postural and positioning difficulties, as well as subsequent detrimental physiological changes: muscle imbalances, stiff joints, muscle necrosis and spinal disk degeneration.

POSTURAL AWARENESS TECHNIQUES

Maintain the low back curve. Research shows that maintaining the low back curve—the lumbar lordosis—when sitting can reduce or prevent low back pain (Figure 3).[8,9] The following practices can help maintain the low back curve.

- Tilt the seat angle slightly forward five to 15 degrees to increase the low back curve.[10] This will place your hips slightly higher than your knees and increase the hip angle to greater than 90 degrees, which may allow for closer positioning to the patient. Chairs without the tilt feature can be retrofitted with an ergonomic wedge-shaped cushion.
- Sit close to the patient and position knees under the patient's chair if possible. This can be facilitated by tilting the seat and using patient chairs that have thin upper backs and headrests. For some operators, this positioning may cause shoulder elevation or arm abduction. In such cases, a different working position should be assumed.
- Consider using a saddle-style operator stool that promotes the natural low back curve by increasing the hip angle to approximately 130 degrees. Using this type of stool may allow you to be closer to the patient when the patient chairs have thick backs and headrests.
- Adjust the chair so your hips are slightly higher than your knees and distribute your weight evenly by placing your feet firmly on the floor. The forward edge of the chair should not compress the backs of your thighs.
- Use the lumbar support of the chair as much as possible by adjusting the lumbar support forward to contact your back.
- Stabilize the low back curve by contracting the transverse abdominal muscles. To do this while sitting, sit tall with a slight curve in the low back, exhale, pull your navel toward the spine without letting the curve flatten. Continue breathing while holding the contraction for one breath cycle. Repeat five times. Strive to maintain this stabilization regularly throughout the workday.
- Pivot forward from your hips, not your waist. Stabilize the low back curve by performing the previous exercise before pivoting forward.

Use magnification. Proper selection, adjustment and use of magnification systems have been associated with decreased neck and low back pain, as they allow operators to maintain healthier postures.[11] Keep the following in mind when choosing and using a magnification system.

- Operating telescopes or loupes are available with flip-up or through-the-lens designs. The declination angle of the scopes should allow you to maintain less than 20 degrees of neck flexion. Working in postures with greater than 20 degrees

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of neck flexion have been associated with increased neck pain.[12] You should try several operating telescope models to determine which suits your needs and fits you best.

- The working distance should allow you to maintain optimal posture, with your shoulders relaxed and your elbows close to your sides.
- Magnification of ×2 will allow you to see working field detail that is approximately identical to that you would see when hunching over the patient without scopes. Magnification greater than ×2 provides enhanced visual detail but a smaller field of vision.
- Operating microscopes allow for the highest magnification of available systems with the greatest operating detail and promote the most neutral postures by design.

Adjust operator chair properly. According to Chaffin and colleagues,[10] the era when sitting work posture problems were solved by simply providing a chair is over. Operators need to know how to adjust the features of their chairs to obtain maximal ergonomic benefits.

- Adjust your chair first. A common mistake operators make is positioning patients first, and then adjusting their chairs to accommodate the patients. Allowances can be made when working with patients who are elderly or disabled.
- Position the buttocks snugly against the back of the chair. The edge of the seat should not contact the backs of the knees. A seat that is too deep can encourage you to perch on the edge of the seat.
- Place feet flat on the floor and adjust the seat height up until thighs gently slope downward while the feet remain flat on floor. This helps maintain the low back curve and enables you to position your knees under the patient more easily.
- Move backrest up or down until the lumbar support nestles in the natural lumbar curve of the low back. Then angle the lumbar support forward to facilitate contact with the low back.
- Tilt the seat forward about five to 15 degrees. If you are beginning to work with the seat tilt function, start with a slight tilt and later increase the degree of tilt as is comfortable.
- Adjust armrests, which are designed to decrease neck and shoulder fatigue and strain, to support elbows in the neutral shoulder position.

There are many ergonomically designed operator chairs available. Because of varied operator body sizes and needs, you should try out several chairs on display at dealer showrooms or in the workplace. Many manufacturers and dealers allow for in-office trial periods, enabling operators to evaluate which model best suits their needs.

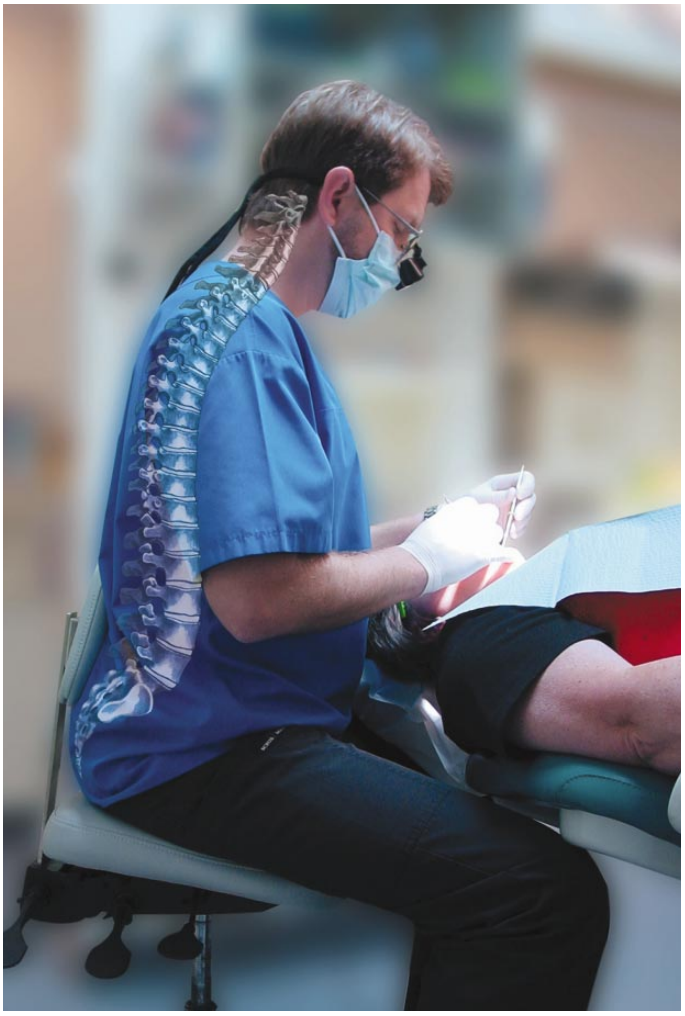

Figure 3. Maintaining the low back curve facilitates proper posture and reduces pressure on disks and muscles.

POSITIONING STRATEGIES

Avoid static postures. According to Lehto and colleagues,[13] the concept of a single correct work posture may be physiologically invalid, as the human body may be made for movement and ever-changing postures.

Some dental schools and educational programs stress the importance of using one "home" position while working. While it is important to use ergonomically correct positions and postures, some studies suggest that several home positions may be better than one.[9,14,15] Spending long periods in static positions increases a worker's

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susceptibility to injury due to the mechanisms we discussed in a previous article.[1] Increasingly, the literature supports the idea that workers should vary their work positions as often as possible to shift the workload from one group of muscles to another.[6,9,10,14,15]

Alternate between standing and sitting. Standing uses different muscle groups than does sitting; therefore, alternating between the two positions lets one group of muscles rest, while the workload is shifted to another group of muscles. Alternating between standing and sitting also can be an effective tool in preventing injuries.[15] One study revealed that dentists who worked solely in a seated position had more severe low back pain than did those who alternated between standing and sitting.[16]

Reposition the feet. Subtle changes in foot position can shift the workload from one group of low back muscles to another, allowing the overworked tissues to be replenished with nutrients.

Position patients at the proper height. A common mistake among dentists is positioning patients too high. This causes elevation of the shoulders and abduction of the arms, leading to prolonged static muscular tension in the neck and shoulders. Magnification enables operators to maintain a greater working distance and position patients at the proper height, with the shoulders relaxed and the forearms approximately parallel with the floor.

Operators should take the time to position their patients properly for mandibular and maxillary procedures. Generally, patients should be placed in a semisupine position for mandibular procedures and a supine position for maxillary procedures.

Avoid twisting. Operatory design plays an important part in how often dentists perform detrimental twisting movements during the workday. Rear delivery systems encourage extensive trunk twisting and shift of vision to retrieve instruments, and side delivery systems require moderate twisting. Transthorax (or over-the-patient) delivery systems minimize twisting and shift of vision. When possible, dentists should position instruments within easy reach. If the operatory design requires the dentist to turn to retrieve instruments or handpieces, the dentist should swivel the chair to face the area squarely instead of twisting the torso. Operators should try to retrieve items with the closest hand, especially with rear delivery systems, to avoid twisting or reaching across the body. Repeated unilateral twisting in one direction may result in muscle imbalances or structural tissue damage, leading to low back pain.[17,18]

A common mistake among dentists is positioning patients too high.

PERIODIC BREAKS AND STRETCHING

Chairside directional stretching. Studies suggest that the increase in operator pain since the 1960s may be due to longer work periods without breaks, due in part to the use of four-handed dentistry techniques.[14,19] Having operators take frequent breaks[20] and reverse their positions is integral in an effective injury prevention program.

It is difficult for most dental operators to avoid PSPs. In optimal PSPs, muscle ischemia and joint hypomobility can occur due to prolonged muscle contractions. When assuming awkward PSPs, dental professionals are predisposed to developing muscle imbalances caused by repeatedly flexing forward, bending to the side and rotating in one direction. In general, dentists tend to lose flexibility in the direction opposite to that in which they are postured statically during the day.[21]

Stretches performed in the reverse direction of awkward PSPs may prevent muscle imbalances that can lead to pain and MSDs. Directional stretches can be performed in or out of the operatory and can be incorporated into a daily routine that facilitates balanced musculoskeletal health. Directional stretching involves a rotation, sidebending or extension component that generally is in the opposite direction of that in which the operator frequently works (Figures 4A-4D). This strategy addresses the muscle imbalances that tend to develop.

Frequent stretching breaks address the detrimental physiological changes that can develop while working in optimal or awkward PSPs: ischemia, trigger points, muscle imbalances, joint hypomobility, nerve compression and disk degeneration. Furthermore, stretching

- increases blood flow to muscles;
- increases production of joint synovial fluid;
- reduces formation of trigger points;
- maintains normal joint range of motion;
- increases nutrient supply to vertebral disks;

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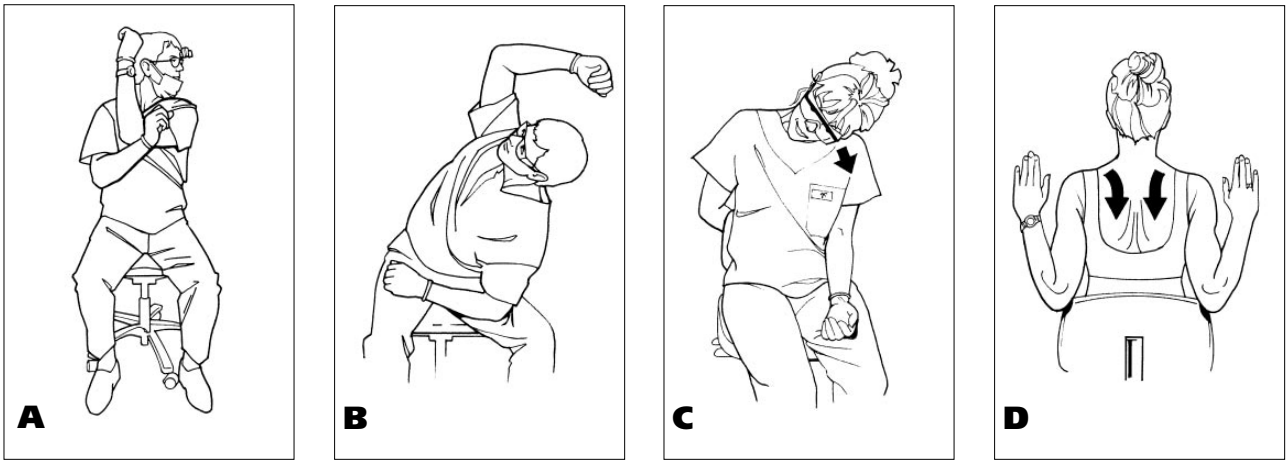

Figure 4. Examples of chairside directional stretches. A. Neck and shoulder combination. With the elbow at shoulder height and at a 90-degree angle, gently pull the arm across the front of body with opposite arm. Look over the shoulder being stretched and hold for two to four breathing cycles. Repeat. B. The untwister. With the knees wider than shoulder width, bend to the left side, resting the full body weight through the left elbow on the left knee. Stretch the right arm overhead and look toward the ceiling. Hold for two to four breathing cycles. Repeat. C. Upper trapezius stretch. Anchor the right hand behind the seat of the chair. Gently bring the left ear toward the left armpit. Hold for two to four breathing cycles. Repeat. D. Downward squeeze. Assume a neutral head posture (ears over the shoulders) and do not let the head move forward throughout the exercise. Lift the chest upward, position the arms at the sides with fingers pointing upward and palms facing forward. Roll the shoulders back and down, squeezing the shoulder blades downward and together. Hold for one long breath cycle. Repeat five times.

- creates a relaxation response in the central nervous system;
- warms up the muscle before beginning to work;
- identifies tight structures that may be predisposed to injury.

How to stretch safely. To avoid injury during stretching, keep the following tips in mind:

- assume the starting position for the stretch;
- breathe in deeply;
- exhale as you slowly increase the intensity of the stretch up to a point of mild tension or discomfort;
- hold the stretch for two to four breathing cycles;
- slowly release the stretch and return to neutral position;
- repeat the stretch if time allows;
- avoid stretching in a painful range and discontinue stretching if it increases pain.
- perform stretches in both directions to detect unilateral tightness (Figures 4A-4C illustrate stretching in one direction only);
- perform directional stretches primarily toward the tightest side throughout the workday and perform the stretches in both directions at home.

Stretching during microbreaks. To prevent injury from occurring to muscles and other tissues, the operator should allow for rest periods to replenish and nourish the stressed structures. If these breaks are too far apart, the rate of damage will exceed the rate of repair, ultimately resulting in breakdown of tissue. According to Karwowski and Marras,[6] resting for more than 50 seconds does not result in an increased force-generation capacity, or strength, of the muscles. This indicates that to optimize the strength capacity of the worker and minimize the risk of experiencing muscle strain, following a schedule of brief, yet frequent, rest periods would be more beneficial to workers than would lengthy infrequent rest periods.

In a study on the efficacy of microbreaks during the workday, McLean and colleagues[22] found that by complying with regularly scheduled microbreaks, the subjects had less discomfort and that the addition of 30-second microbreaks showed no detrimental effect on worker productivity. Other authors have pointed to the efficacy of using micropauses and stretching during dental procedures.[23-25] Stretches can be modified so that dental operators can perform the stretches easily at chairside, while wearing their gloves (Figure 5). Operators should perform directional stretches regularly throughout the day, both in and out of the operatory setting. They also can benefit by walking or performing other activities involving

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Figure 5. Chairside stretching can be performed during breaks such as while waiting for anesthetic to take effect in the patient.

movement during longer breaks.

Trigger points. Sometimes, operators may experience pain that is not relieved with stretching but instead worsened by it. This pain may be caused by a sustained contraction inside a tight band of muscle known as a trigger point, which feels like a small hard knot.[26] When firm pressure is applied, trigger points are painful and may refer pain to another area. They do not allow the muscle fibers to contract or relax; therefore, they effectively decrease flexibility and reduce blood flow to the muscle. It is important that operators release trigger points as soon as possible. Various people can help treat trigger points:

- a physical therapist trained in trigger point therapy, contract and relax technique or muscle energy technique;
- a neuromuscular therapist;
- a massage therapist trained in trigger point therapy;
- a physician trained in spray and stretch technique or trigger point injection;
- the dentist self-administering trigger point therapy using a tennis ball or other small ball between the back and a wall or using a trigger point self-massage tool.[27]

STRENGTHENING EXERCISES

MSDs in dentistry often begin with fatigue of the postural stabilizing muscles of the trunk and shoulders. As these muscles fatigue, operators tend to slump into poor posture, setting the stage for injuries. Dentists should perform specific strengthening exercises for the trunk and shoulder girdle to enhance the health and integrity of the spinal column, maintain good

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working posture, optimize the function of the arms and hands and prevent injuries.

Areas to strengthen include the trunk stabilization muscles, primarily the transverse and oblique abdominal muscles and multifidus muscles; the stabilizing muscles of the shoulder girdle, mainly the middle and lower trapezius muscles; and the downward gliding muscles of the rotator cuff, the infraspinous, subscapular and teres minor muscles. Dentists should avoid overstrengthening the chest and anterior neck musculature, deltoid muscles and upper trapezius muscles, as this may exacerbate muscle imbalances to which they are prone. Areas to stretch include the chest musculature, hamstring muscles, low back muscles, buttock (piriform) muscles and hip flexor (iliopsoas) muscles. This combination of strengthening and stretching addresses a unique pattern of muscle imbalances that can develop among dental professionals.

Aerobic exercise should be performed three to four times a week for at least 20 minutes.

Guidelines for exercise. Certain guidelines should be observed when beginning any exercise program:

- consult a physician before beginning any exercise program;
- do not perform strengthening exercises for painful or fatigued muscles;
- begin exercise gradually, starting with the minimum number of repetitions;
- stop exercise immediately if numbness, tingling, dizziness or shortness of breath occurs;
- perform strengthening exercises three to four times per week and stretching exercises daily;
- always exercise in a pain-free range.

Aerobic exercise. Aerobic exercise should be performed three to four times a week for at least 20 minutes. One major contributing factor to MSDs is decreased flow of nutrients and oxygen to muscles.[1] Aerobic exercise increases blood flow to all of the tissues in the body and improves their ability to use oxygen. In addition, aerobic exercise improves cardiovascular and cardiorespiratory function, lowers heart rate and blood pressure, increases high-density lipoprotein (good) cholesterol, decreases blood triglycerides, reduces body fat, improves stress tolerance, increases mental acuity, improves sleep quality and may increase longevity.[28] Operators should choose aerobic exercises that they enjoy. It is advisable to do at least two types of aerobic exercise regularly, for both variety and the benefits of cross-training. The results of a study assessing the musculoskeletal symptoms of dentists found that physical exercise can be a buffer against musculoskeletal ill health and stress for dentists over a wide range of ages.[13]

Stress management. It generally is accepted that dentistry can be a stressful occupation. Stress can elicit muscular contraction and pain, especially in the trapezius muscle.[29] Operators may use various stress-reduction techniques to decrease stress-related muscular tension. They include breathing techniques, progressive relaxation, visualization, massage, aerobic exercise, meditation or yoga.

EDUCATION

As professionals, dentists understand the concept of being lifelong students so they can maintain their proficiency in clinical techniques that benefit their patients. To protect their own health, dentists should seek out and receive education about musculoskeletal health, injury prevention and dental ergonomics. Ideally, this education should begin during dental school and continue through the dentist's professional life.

One dentist, however, has found that injury prevention and dental ergonomics education still is in its infancy.[25] Most dental practitioners have not been trained in these areas, and they have not developed the skills and knowledge necessary to practice in a manner that is ergonomically correct. This lack of training is due in part to the need for more research and for better teaching tools and better-informed and -trained teachers. Part of the blame for the lack of training can be attributed to the magnitude of the task.

Dental operators can be taught to manage and prevent injuries effectively. They can educate themselves and their staff members using a multifactorial approach that includes preventive education, postural and positioning strategies, proper selection and use of ergonomic equipment, and frequent breaks with stretching and strengthening techniques before painful episodes occur. Prevention strategies should be easy to use to ensure long-term compliance.

CONCLUSIONS

Work-related pain is common among dental professionals. The development of four-handed oper-

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atory 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 multifactorial, any possible solution should be multifactorial as well.

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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. This represents a paradigm shift for daily dental practice. 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. ■

Dr. and Ms. Valachi are co-founders of Posturedontics, a company that provides continuing dental education courses on topics that are addressed in this article.

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