Ergonomic principles in the dental setting: Part 1

Creating ergonomic conditions in the operatory benefits the doctor, staff members, and patients. Specific design, instrumentation, and positioning principles can be implemented to help prevent musculoskeletal injury and reduce errors.

By Dr. Michael Dougherty

The Ergonomic Standard mandated by the Occupational Safety and Health Administration (OSHA) recommended that the most efficient and effective way to remedy "ergonomic hazards" causing musculoskeletal (MSK) strain should be through engineering improvements in the workstation.1 Although Congress withdrew the OSHA ergonomic regulations before they were to be implemented, Secretary of Labor Elaine Chao has promised to "pursue a comprehensive approach to ergonomics, which may include new rulemaking." Making employers more accountable for the physical environment in which they and their employees practice in turn encourages manufacturers to develop more ergonomically designed delivery systems. Led by the American Dental Association's "Ergonomic Summit"2 endorsement in August of 2000, dental manufacturers began to look more intently at ways to improve the ergonomics of the equipment and instruments they provide to the profession.

Ergonomic conditions are simply the safest, most efficient, and easiest way to work.3 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.

It doesn't take long to find a peer who has experienced an MSK disorder associated with accessing intraoral structures (Figure 1 illustrates a popular operating posture that may cause such problems). According to OSHA, ergonomic conditions are desirable because they prevent repetitive MSK injuries and reduce errors that lead to accidental injuries to employees.1

Fig. 1 A dentist's typical operating posture.

Ergonomic conditions also provide a safer environment for patients-fewer mental distractions and reduced positioning and avoidance acts all result in less physical strain on the operator. Studies of human factors have established the best position for controlling the fingers during clinical operations that require fine motor skills. It may be time to look at this body of knowledge to establish a direction for dental equipment design. Because the ergonomic standard has been rescinded, the standards it set are not officially a concern for dentists as employers. Nonetheless, the well-being of dental care workers should still remain a primary concern, given recent research findings concerning the MSK health status of dental professionals.4,5 The discovery of numerous injuries to dentists and staff members resulting from providing routine dental services underscores the need for concern about injury prevention in the workplace, even though the welfare of the patient has always been and still remains our primary concern.

This first of a two-article series discusses ergonomic standards for designing delivery systems for

dental care. The second (to be published in July DPR) will illustrate the integration of a human-centered design into the dental operatory and discuss new standards for dental instruments and devices.

Originally, the word "ergonomic" was defined as the amount of effort, measured in ergs and dynes, that was necessary to perform a task. Less effort expended indicated a more ergonomic condition. OSHA refers to the word "ergonomic" as the relationship of the human/environmental interface that does not produce injury. This definition carries more meaning than the term originally did when it was first introduced over a century ago. To include how the human/environmental interface affects us, this more expanded definition of the word "ergonomic" rates the ergonomics of the human/environmental interface according to four human functions: sensing, working, positioning, and avoiding. As illustrated in the graphic on page 73, these four functions are listed left to right in order of importance for performing any task. The same order reflects the increasing likelihood that these functions will cause an injury.

Avoiding objects such as chairbacks, headrests, patients' shoulders, and trays is the worst physical accommodation dental care providers make. These accommodations are reflected in clinicians and staff twisting and bending, laterally extending elbows, tilting the head off-center to the shoulders, and straining against gravity for hours at a time.

The more positioning that is required of instruments, devices, materials, patients, and ourselves, the less likely that dental operators will re-establish their best position. The act of repositioning leads to compromised postures, compromised control of the fingers, errors of cognition that cause injuries such as bur and needle sticks, collisions with operating lights, reaching out of the "clean operating zone," and ultimately, to the degeneration of the MSK system. Also contributing to the operator's physical fatigue are strained posture caused by the tilting of patients, use of non-ergonomic instruments, the failure to use the dental mirror, and inadequate lighting.6

Both avoiding and positioning other objects, such as operating lights and handpiece holders, compromises operator attention while performing intraoral tasks. Randomly positioned devices increase the chance of error proportional to the range of positions that the device can be placed. Constantly keeping track of an unstable environment challenges the operator cognitively to pay attention to multiple decisions unrelated to the actual operation. Cognitive demands associated with sighting off the level horizon and off the midline of the operator's body are additional conditions that are hazardous to both the operator and the patient. Sighting off the horizon, or tilting the head so that the ocular plane is no longer parallel to the horizon, is hazardous since this further challenges dentists' ability to control their fingers accurately in the patient's mouth, resulting in mental fatigue and the likelihood of more errors. Dental operators have long done an excellent job of providing their services. Now it must be asked, "At what cost to themselves?"

Many studies have been conducted4 or are currently underway (A. Fast, personal communication, May 2000) to document the degree of strain a dental operator is subjected to in current professional settings. These studies suggest a need for a work pattern analysis in dentistry, particularly because a large number of worker's compensation and disability insurance claims are forcing early retirement and workdays lost due to an MSK injury.

To maintain this position of optimal control, an equipment setting should fit the operator like a suit of clothes, preventing the operator from straying from this best position. The best position of the operator's head, body, and fingers is determined by masked-eye tests using the proprioceptive (feel-based) senses of the body. The location where subjects report they feel their fingers have maximum control for fine motor operation has been determined from the results of thousands of masked-eye tests. The masked-eye studies were conducted by asking individuals with their eyes covered to avoid thinking about existing equipment, instruments, or past habits. These subjects then placed their dominant index finger in a position they felt provided them with maximum control of it while imagining performing the "most" minute movement possible.

The results of these tests for the most comfortable, preferred operating position for performing various simulated dental procedures were as follows:

1. The dominant-hand index finger is positioned at or about the armpit level.

2. The dominant-hand index finger is positioned in the midline of the seated dental operator's chest.

3. The operator sits in a free upright posture without back support.

These individually determined operating conditions, illustrated in Fig. 2, maintain the alignment of the vertebrae-and hence, the health of the dentist's neck and back during his or her career.

Fig. 2 The preferred operating position for most dental procedures.

The position that sitting subjects (including those not trained in the dental profession) reported feeling most physically comfortable while pantomiming precise operations with their fingers (with no preconceptions or defense against past habits) was, on average, 103.2 cm from the floor for men and 96.2 cm from the floor for women. This location, termed the "zero point" for the mouth of the patient, can be specified by the intersection of the occlusal plane and the midline of the maxilla and is dependent on the proprioceptively derived seat height of the operator. From this optimal position, the operator should be able to orbit around the patient's head from 2 o'clock to 10 o'clock, unobstructed by any supporting structures or by the assistant (see Fig. 3). The "orbiting range" from 12:30 to 10 o'clock is common for right-handed operators. For left-handed operators, the common orbiting range is from 2 o'clock to 11 o'clock.

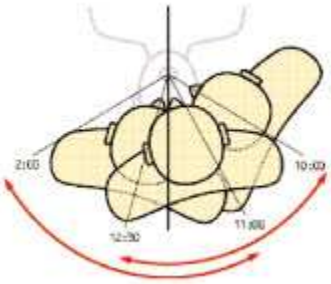

Fig. 3 The orbiting range around the patient's head should be unobstructed.

Operating height is the most important condition for maintaining the unstrained posture of the dental operator. An ergonomic dental treatment setting should allow the free orbiting range of the operator at an operating height determined by the provider. The patient lies in a full rest (supine) position because this has provided the dentist with the best position for applying vector forces to the teeth and the best access to the mouth, according to proprioceptive derivation. The distance from the floor to the patient's "zero point" is the most important dimension for the dental care worker to acquire before beginning intraoral treatment on each patient.

Data indicate that dentists typically do not take enough time to adjust the height of the patient's support to secure the best operating height for their personal anatomic requirements. The amount of time it takes the seated operator to elevate a patient to optimal height in most dental chairs is approximately five seconds. The average adjustment of the height of the patient support from entry level to operating height is taking dentists less than three seconds (T. Taniguchi, personal communication, March 1, 2001).

Because many patients are not optimally positioned, a function automatically returning the chair to the desired height could break the habit of stopping patient elevation before achieving the best operating height. This individually determined operating condition maintains the alignment of the vertebrae and hence, the health of the dentist's neck.

These positions, as illustrated in Figs. 4 and 5, give the best access to the mouth and provide stabilization of the fingers on intraoral points. Headrests should be designed to position the maxillary plane of the patient in this range to also enhance the operator's ability to achieve sightings of operating points. While positioning the head of the patient to provide for neutral posturing, the

operator decides whether indirect (reflected) vision is needed for the procedure to be performed. Positioning of the mirror, if needed, is coordinated with the movements of the fingers of the operating hand. The headrest design should readily allow the patient's head to be lifted or lowered into position and/or rotated side-to-side upon the axis of rotation of the patient's cervical spine. The headrest should not interfere with the patient's ears when the head it rotated.

Fig. 4 An ergonomic headrest provides the best access to the mouth, finger stability, and views of the mouth with a few simple adjustments in the "Y" plane.

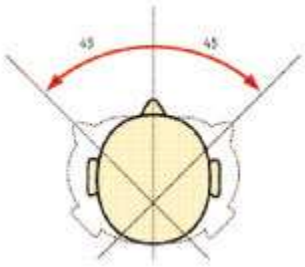

Fig. 5 An ergonomic headrest also provides for axial rotation of the patient's head in the "X" plane.

Most dentists will need to complete skill courses to master access, contacts on instruments, stabilization of the fingers, and views of the operating point.8,9 Headrest design is instrumental in the positioning of the oral cavity for the application of these new skills.

Because the patient now is lying horizontally, the dentist needs to avoid the patient's shoulder and chest during intraoral procedures. Compromise of the operator's best finger control begins when the shoulder of the patent interferes with the orbiting operator's elbow. It is the lifting of the elbow, as well as the off-axis rotation of the operator's head on his or her spine, that require more effort to control the fingers. Strain on the cervical spine should not be overlooked when considering conditions for optimal performance. Designing patient supports and instruments that limit the need for the operator to change positions and that prevent operators from straying out of their preferred operating zone will enhance the dental care provided, will minimize stress and strain, and consequently, will reduce the risk of musculoskeletal injuries. Thus, equipment designed to optimize the ability of seated dental care workers to work skillfully in the preferred orbiting range will reduce the need to work in compromised positions. Further refinement of finger skills and operating views allows the provider to operate from a few choice positions within this range.

Dental operators should assume their best position and then, through the least-strained, masked-eye 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. This 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.

Type 1 (Fig. 6): Instrument and tubing supports that move with the patient's upper body. Outlets for air, water, vacuum, and electricity that supply the instruments extend from the outline of the patient support at the shoulder and upper-arm locations.

Fig. 6 Type 1: Instruments and tubing supports move with the patient's body.

Type 1.1: Stable type (does not tilt the patient)

Type 1.2 : Chair type

Type 2 (Fig. 7): Instrument and tubing supports are chair-mounted and designed for hand or motorized positioning.

Fig. 7 Type 2: Instruments and tubing supports are chair-mounted.

Type 2.1: No instrument supports (includes tray) on top of or in front of the patient.

Type 2.2: One or more instrument or tubing supports on top of or in front of the patient.

Type 3 (Fig. 8): Patient supports and instrument/tubing supports are separate.

Fig. 8 Type 3: Patient supports and instrument/tubing supports are separate.

Type 3.1: Fixed on floors, walls, and ceiling or into cabinets (non-mobile).

Type 3.2: Moves on wheels, slides, or on hinged arms.

When making a decision to choose ergonomic dental equipment, this question must be answered: "What body conditions and position(s) do I want in order to perform the safest, most efficient dental procedures?" Because of interest in ergonomic standards, dentists must now ask themselves if they are happy with their present delivery conditions.

Repositioning and avoiding equipment to achieve and/or maintain the best posture are "ergonomic hazards" in the dental treatment setting. Repositioning and avoiding create fatigue, confusion, and repetitive musculoskeletal injuries for dentists, hygienists, and assistants. Stabilizing the adjustable operatory setting, improving finger skills, and developing human-centered instrument and equipment designs will eliminate these problems and enhance the performance of the operator and the well-being of the operator and the patient. Furthermore, placing the operating point at a height that facilitates the best control of the operator's fingers also stabilizes the vertebrae against gravity. Unfortunately, prevailing dental chairs with limited vertical rise force dentists and hygienists to crouch over their patients, who are positioned horizontally.

Finally, the distance from the floor to the position some individuals need for the best control of their fingers may be as much as 120 cm. Currently, there is no dental chair available in the United States that delivers the "zero point" of a patient to this distance, unless it is mounted on blocks. The best position of the operator for finger control and views of the oral cavity (direct and/or indirect) is the starting point for designing the ergonomic dental workstation of the future. OSHA's original Ergonomic Standard for Small Businesses has triggered interest in Type 1 delivery design, with its own instrument specifications, cabinets, and office layout.

Part II of this series will focus on considerations for transitioning from prevailing dual-entry/power wall operatory design to the feel-based operatory design of the future. This second part will reveal a needed and progressive change from a product-based operatory to a systems-based operatory. nDPR

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