Regulation
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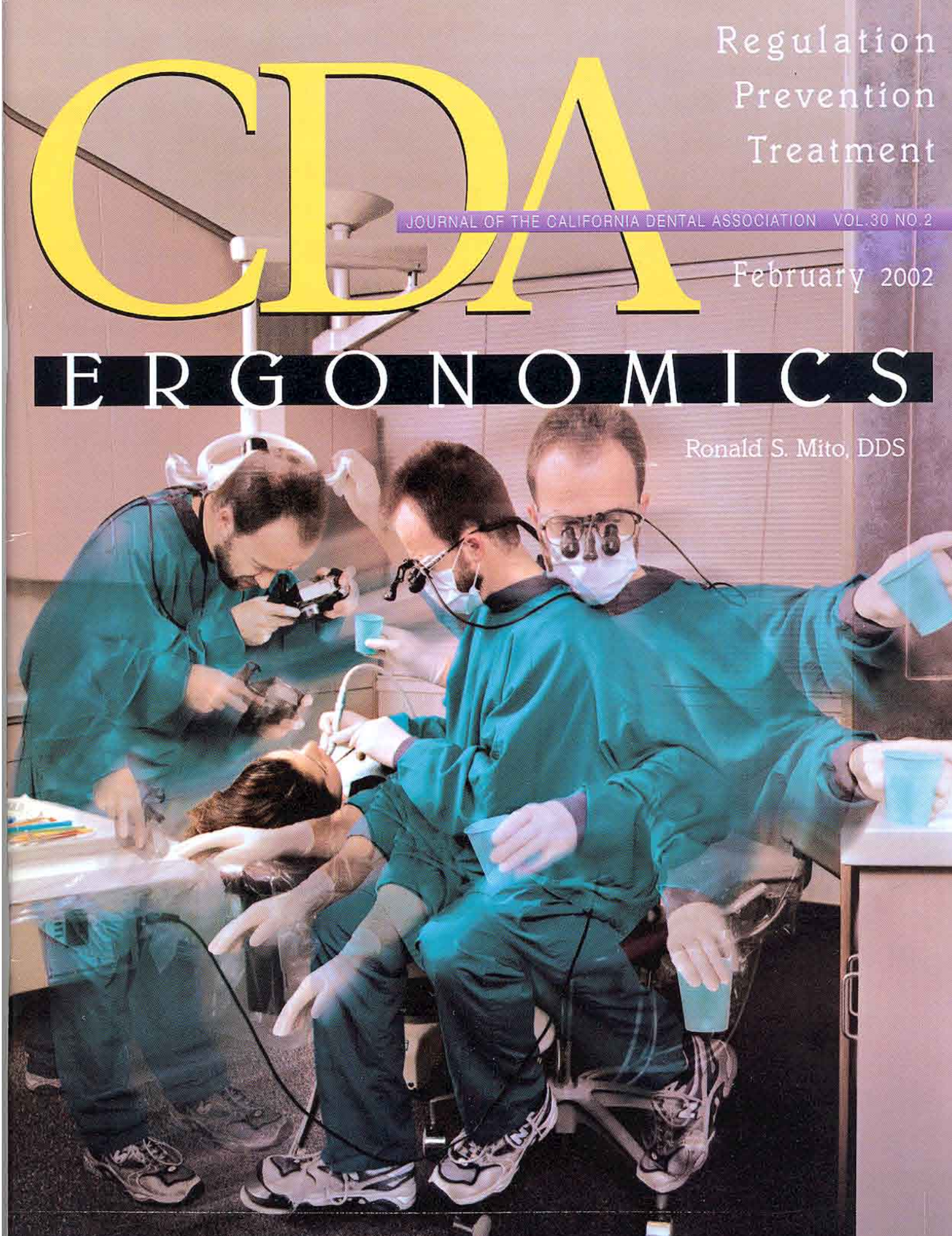
ERGONOMICS

Ronald S. Mito, DDS



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DEPARTMENTS

FEATURES

CDA JOURNAL, VOL 30, Nº2

It's a New Day

Jack F. Conley, DDS

In this space in October 2001, Journal Associate Editor Steve Gold commented about change. We were reminded by a professional uprising of sorts late last year, that the profession, like every other segment of the society, had entered into the 21st century some 12 to 24 months ago, but was not entirely ready to respond with enthusiasm to a procedural "change" that was necessitated by a new legislative requirement to distribute a new Dental Materials Fact Sheet developed by the Dental Board.

In our continuing effort to keep the membership well informed, the Jan. 4 letter from President Steven Chan, which provided the history and the facts behind this new requirement, is reprinted here. CDA Update and CDA Online had reported both the Dental Board activity and the legislative activity surrounding this issue, which has been summarized in the letter. It should not have been an end of the year surprise to anyone with access to CDA membership information.

It is particularly important to emphasize the importance of CDA Online. It is a members' nonstop source of information. From legislation to continuing education, it is the medium of choice for members to stay informed with information of essential value in the fast-paced world of contemporary business. If you misplace your copies of the Update of Journal, or someone in the office or home accidentally tosses them out, you can easily access articles, news items, or scientific manuscripts on CDA Online. Everything that affects us can be found there. CDA's position on legislative issues, significant Dental Board Regulations, OSHA regulations, registration for CDA Scientific Sessions -- they can all be found on CDA Online. Our point here is that CDA Online is an essential business tool that we must train ourselves to utilize if we are to be well-informed. CDA staff can and will provide membership service assistance, but what can be faster than CDA Online?

As noted in the letter from President Chan, CDA Online has featured both the Fact Sheet, the frequently asked questions, and a sample patient acknowledgement form that can be downloaded and copied for some time. The latter two items were printed for a second time last month in Update. Some component societies (mine included) have provided members with the acknowledgement form for the purpose of making copies. In this day of copy machines, provision of one-time copies can be relatively quick and inexpensive without having to resort to a special printing that would only develop a costly inventory of forms.

We are the trusted source of dental information, or at the very least that is an objective of our professional organization; and it should be a key in our individual relationships with patients. While yours truly doesn't appreciate the added procedures any more than the average colleague, I believe it is a measure we can live with, at least until a more practical procedure might be developed in the future. And to do our part in making CDA

CDA JOURNAL, VOL 30, Nº2

the trusted source, we members can use discussion of the Dental Materials Fact Sheet with patients to help us fulfill our professional responsibility to provide and disclose such information to our patients.

As noted in the letter, keep in mind that safety concerns about the mercury in amalgam and anti-amalgam litigation against CDA and ADA have been hovering over dentistry during this past year. CDA staff, and the legal department in particular, spent many hours on our behalf in 2001 trying to bring resolution to the Proposition 65 issue and to the lawsuits served on CDA and ADA. For the past 12 months, we have experienced an extremely difficult environment, spearheaded by sometimes emotional legal and legislative agendas

Our membership in organized dentistry continues to provide us with valuable resources unavailable to nonmembers in facing these challenges and changes, whether it is through CDA Online or by CDA or component staff effort.

It is a new day. But this practitioner is confident that dentistry will adapt to the mandate of this legislation. Stay informed through publications and CDA Online. They will help create a better understanding of the how and why of mandated initiatives. We should not be surprised by these kinds of changes. Instead, we should be constantly preparing ourselves through study of the educational and informational resources available to all members to positively respond to them.

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Letter from Dr. Chan

Jan. 4, 2002

Dear Colleague:

Happy New Year! On behalf of the officers and trustees of CDA, I wish you peace and prosperity in the coming year.

This letter is intended to apprise you of issues surrounding the revised Dental Materials Fact Sheet (DMFS) by the Dental Board of California (DBC), and the implementation of SB134 (Figueroa), requiring dentists to provide a copy of the DMFS to patients prior to performing restorative dental treatment. A copy of this fact sheet was recently provided to each California licensee directly from the DBC, though unfortunately no instructions were included. While we have attempted to keep you informed of the specifics of this law, the number of inquiries received indicates that additional information is needed. This letter will explain how the law came about, to whom it applies and how to comply.

This fact sheet is not new. In 1992, the Legislature first required the DBC to develop a Dental Materials Fact Sheet and make it available to every dentist. The law encouraged practitioners to discuss with patients the dental materials used in restorative procedures, including advice on the risks and benefits. It was the passage of SB 134 in 2001 that set forth new requirements (effective January 1, 2002). The new law provides that:

- The fact sheet must be provided once to every new patient and to patients of record prior to the performance of restorative procedures.
- An acknowledgment of receipt of the DMFS must be signed by the patient and placed in the patient's record.
- If the board updates the fact sheet, the revised fact sheet must be given to patients as provided above. A dentist must also provide the fact sheet to any patient upon request.
- "How did this requirement come about?" For several years, there has been increased attention on products containing mercury by consumer activists, environmental groups, regulatory officials and dentists. This influenced legislative developments in California and other states. In late 2000, the Legislature began hearings to review the Dental Board's operations. Committee members expressed concern that the DMFS adopted in 1992 had not been updated, and that the Board had not fulfilled its responsibility. At these hearings, representatives from Consumers for Dental Choice spoke about the hazards of dental materials -- specifically amalgam. They lobbied for a ban on the use of amalgam. Because of information provided by CDA regarding the safety and efficacy of amalgam and the current scientific literature supporting its continued use, the Legislature lost interest in a ban. They focused instead on ensuring that patients were informed about dental materials.

Concerns regarding the overall effectiveness of the Dental Board continued to grow. As part of the Dental Board sunset legislation, the committee, determined to ensure that patients had access to pertinent information, considered statutory requirements of informed consent, posting of the fact sheet in the dental office and broader requirements for distribution. It was through the lobbying efforts of CDA that these requirements were deleted. Providing the DMFS to patients prior to performing restorative dental care then became the focus. The 1992 law encouraged discussion of the DMFS with patients. Legislators were convinced that patients were not

CDA JOURNAL, VOL 30, Nº2

getting adequate information, and were sensitive to the increased scrutiny on all mercury-containing products. "Encouraging" discussions was no longer sufficient, and a call for documentation was made. While not a perfect solution, accepting CDA's modifications greatly reduced the requirements on the profession while still meeting the author's goal. All of this was happening while there were rumblings about Proposition 65 warnings for mercury in amalgam, and a bill banning the use of most mercury-containing products was finding its way to the Governor.

This new law encourages dentists to discuss dental materials with patients and requires them to provide a copy of the fact sheet to every new and existing patient prior to performing restorative dental treatment. There is no requirement to engage in a lengthy discussion; the intent is to provide patients with the information necessary to make educated decisions. If you do not perform restorative procedures, it is not necessary to provide the fact sheet.

In the January issue of the CDA Update, a copy of the DMFS, a frequently asked questions sheet and a suggested acknowledgement form will be provided. You may make copies for your patients. You may also download the fact sheet from the board's Web site at www.dbc.ca.gov or via CDA's Web site at www.cda.org. Finally, you may call CDA for additional information or copies. The least expensive method is to simply copy the fact sheet and acknowledgement, using the CDA original. Your component dental society may also have options available.

Failure to comply with this law may subject a licensee to disciplinary action by the DBC. It is unknown at this time, however, exactly what level of discipline the DBC will assign to infractions of this law. First violations could result in a warning, a citation, a fine, or a combination thereof. Repeated violations could result in action being taken against a license. As you begin complying, I also want to assure you that CDA is exploring options to further minimize the impact of this law on your practice, including possible amendment to the requirement during the 2002 legislative session.

It must be noted at this juncture that this will not be the last we hear about mercury in dental amalgam. We are nearing a statewide solution to Proposition 65 notice requirements for mercury, and further communication is likely. In addition, litigation against the ADA and CDA related to mercury is in progress in San Francisco. Those organizations and individuals opposed to its use, including a member of the California congressional delegation, will continue to advocate a ban on amalgam.

We trust this information answers questions regarding the Dental Materials Fact Sheet and the new requirements. Often in cases such as this misinformation abounds. Please be sure to look in the January CDA Update for Frequently Asked Questions, and do not hesitate to contact CDA's Contact Center directly at (800) 736-7701 should you need additional information.

Sincerely,
Steven D. Chan, DDS
President

CDA JOURNAL, VOL 30, Nº2

The Future of Dentistry Report Aims at Helping Dentists and Patients

By Debra Belt

The recently released Future of Dentistry Report has been categorized by some as a blueprint to help guide the dental profession through the trials and tribulations the next 15 years are expected to hold.

As such, the document focuses on strategies that will help the average practitioner negotiate the future world within which dentistry will operate.

ADA commissioned the report in 1999, but it is not a policy document of the association. It was developed by a 16-member oversight committee led by Leslie W. Seldin, DDS, and contains several hundred pages and 114 recommendations.

The report has a specific vision: "Improved health and quality of life for all though optimal oral health." It describes the current status of the dental profession as "strong and healthy," identifies trends such as an expected increase in preferred provider organizations, and outlines challenges such as the geographic imbalances in the dental work force.

So, what does the report mean to California dentists?

"The Future of Dentistry Report is meant to improve the life of anybody connected to the dental profession -- practitioners and staff, as well as the public we serve," Seldin said in a question-and-answer session with the ADA. "It is a roadmap that gives every practitioner in his or her office more tools to provide the very best care to the public. The ultimate goal of the report is to improve the lot of patients and practitioners."

How can a single report, albeit a sizeable one, do this?

As Seldin said, "Everything in the report relates in some way to the practicing dentist."

Take, for instance, the top concerns of CDA dentists as identified in member surveys: third-party issues, the allied health personnel shortage, and regulatory issues.

The report addresses each of these areas, relates each to the overall profession, and offers specific recommendations, which call for a variety of action through such avenues as education, research, finance, or clinical practice.

In addressing the financing of dental services, Seldin notes that it would be shortsighted to ignore the importance of ensuring adequate financing for needed dental care. The report identifies a trend of increasing enrollment in preferred provider organizations and a decline in dental health maintenance organizations. This trend was documented by the ADA Survey Center, which also anticipates an increase in direct reimbursement and more interest in medical savings accounts.

In his overview of the report, Seldin acknowledges that patients are experiencing limitations, restrictions, exclusions, larger co-payments, and administrative problems that, if continued, will lead to growing dissatisfaction with dental insurance plans. Likewise, dentists' frustration with dental benefits companies is also clearly expressed in the report.

The recommendations to address these concerns are in two parts: employer-based dental benefits and innovation in dental financing arrangements. Employer-based recommendations include marketing, organizational, and legislative suggestions. The recommendations include the dental profession encouraging "the dental benefits industry to streamline procedures, reduce administrative burden and policy limitations, and provide greater flexibility for covered individuals."

The report also clearly acknowledges that there is a shortage in the number of qualified allied personnel, including dental lab technicians. Recommendations support increased mobility for hygienists through licensure by credential. Further recommendations encourage workforce studies and advocate the goal of standardization of approved duties for allied personnel within the United States.

Addressing another top concern of California dentists, the regulation of the profession, Seldin states that "in recent years, regulatory activity has had a profound effect on the manner in which dentistry is practiced."

While noting that some regulatory activity has been appropriate and welcomed by the dental profession, the report also points out that much regulation has been criticized for not being sufficiently supported by scientific data. Recommendations suggest that "the profession must continue to be vigilant and proactive in identifying and researching potential hazards that might impact the safety of patients, the dental workforce, and the environment." Further recommendations include the dental profession remaining proactive in advocating scientifically valid solutions to identified hazards.

In working to advance the report and the recommendations it makes, the ADA received a plan to distribute information from the report to the profession and all of the allied organizations. It is expected that repeated exposure to the report will lead to action, ultimately on a global scale.

The full text of the Future of Dentistry Report is available online at www.ada.org in the "Your Practice" content area.

Calcium Crisis Bodes Ill for Bones

Only 13.5 percent of girls and 36.3 percent of boys age 12 to 19 in the United States get the recommended daily amount of calcium, placing them at serious risk for osteoporosis and other bone diseases, according to statistics from the Department of Agriculture. Because nearly 90 percent of adult bone mass is established by the end of this age range, the nation's youth stand in the midst of a calcium crisis.

"Osteoporosis is a pediatric disease with geriatric consequences," said Duane Alexander, MD, director of the National Institute of Child Health and Human Development. "Preventing this and other bone diseases begins in childhood. With low calcium intake levels during these important bone growth periods, today's children and teens are certain to face a serious public health problem in the future."

The health risks related to low calcium intake are not just years away, Alexander explained. Children are drinking more soft drinks and more noncitrus drinks than they used to; meanwhile, milk consumption has dropped. The number of fractures among children and young adults has increased, probably due to lower intakes of calcium. Pediatricians are also seeing the re-emergence of rickets, a bone disease that results from low levels of vitamin D. Rickets became almost nonexistent after vitamin D was added to milk in the 1950s, but is now appearing at greater rates around the country.

But the major effects of this crisis are yet to come.

"As these children get older, this calcium crisis will become more serious as the population starts to show its highest rate of osteoporosis and other bone health problems in our nation's history," Alexander said. "But we need to remember that this is a preventable and correctable public health problem."

Getting children to pay attention to their calcium needs is a challenge for scientists and educators, he added. For this reason, the National Institute of Child Health and Human Development has expanded its Milk Matters calcium education campaign and Web site to speak directly to children and their parents about calcium.

The Milk Matters campaign stresses low-fat or fat-free milk as the preferred source of dietary calcium because:

- Milk has a high calcium content.
- Calcium in milk is easily absorbed by the body.
- Milk contains other nutrients -- including vitamin D, vitamin A, B12, potassium, magnesium, and protein -- that are essential to healthy bone and tooth development.

The Milk Matters Web site is an excellent source for information on calcium for health care professionals. For more information on the Milk Matters campaign, please contact the National Institute of Child Health and Human Development clearinghouse at (800) 370-2943, or visit the Web site at www.nichd.nih.gov/milkmatters.

Scientists Find Hidden Piece of Flu Virus

For nearly 20 years, scientists have labored under the assumption that the influenza virus comprises only 10 protein molecules that form its structure and carry out its activities. However, researchers have reported finding a new, "hidden" influenza virus protein. This protein may kill immune system cells that fight the virus, thereby contributing to the virus's potency, the researchers say.

"We believe this is a groundbreaking finding, although we're not yet sure how deep the ground is," said Jonathan Yewdell, MD, PhD, a viral immunologist who led a team of scientists at the National Institute of Allergy and Infectious Diseases. "This might be the grand canyon' of the flu, in terms of understanding this virus's virulence, or perhaps only a narrow side ravine."

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The scientists turned up this new protein by accident, while sifting through bits and pieces of "junk" peptides, the short protein molecules the virus creates once it infects a cell and begins replicating. They form when the process that translates viral genes into proteins goes awry, Yewdell said. In other words, junk peptides result from genetic mistakes.

"We weren't looking for new proteins at all. We assumed the 10 known influenza proteins were all there were," Yewdell said.

"Like many scientific discoveries, this one happened serendipitously, and it confirms the importance of supporting basic research on infectious diseases," concludes Anthony S. Fauci, MD, director of the institute. "When you have good researchers exploring interesting questions, they are bound to turn up crucial information."

CDA JOURNAL, VOL 30, Nº2

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It Isn't Supposed to Be Like This

By Jeffrey Galler, DDS

Brooklyn, N.Y.

"Have You Gotten Any Calls for X-rays?"

At continuing education lectures, association programs and dental meetings, that is the first question you now hear dentists asking each other. In the past, we talked about the stock market, our practices, families, dental labs, or insurance programs. Now, we discuss providing copies of radiographs so that patients missing in the World Trade Center disaster might be identified. Many of us volunteered to help in the grim task of identifying the deceased by matching the jaw fragments of unrecognizable corpses with dental X-rays.

It Isn't Supposed to Be Like This

Compassionate hands that spent decades learning how to minimize any discomfort that patients might experience, now handle separated body parts of patients who will never again feel pain, and wonder what it must have felt like when their bodies exploded into countless pieces.

It Isn't Supposed to Be Like This

Curious hands that palpated and explored the mastication muscles of dental school cadavers now have the grisly task of wiping charred tissues off mandibles and maxillas so that victims' jaws can be analyzed and identified.

It Isn't Supposed to Be Like This

Nervous hands that examined extracted teeth during dental school tests, hearing professors demand, "Is this a lower right molar or lower left molar?" while wondering what possible difference it could ever make to their future patients, now try to reassemble a lower jaw, fitting broken bony fragments and severed teeth, like a macabre jigsaw puzzle.

Embezzlement causes more than financial damage

Although embezzlement causes financial damage to a dental practice, psychological damage also occurs to the dentist and staff, wrote Gerald Gelle, DDS, in The Bulletin of the Berkeley Dental Society, October 2001.

Theft by someone in a position of trust is usually hard to detect and quite profitable, Gelle wrote. The average case of embezzlement is about $40,000, he said. If caught early enough, the damage to a practice is kept at a financial minimum.

But more than the financial damage is the psychological damage that interferes with the way the office team works together and delivers care.

Gelle said the first part of diagnosing a practice with a suspected embezzler is subjective and intuitive. It requires that dentists look or listen for early behavior warning signs that may or may not be linked to an actual embezzlement. Gelle says being attentive for these signs must be aimed at the practice's bookkeeper, receptionist, office manager, or whoever handles the money in the office.

One example, Gelle noted, is a person who openly resents a substantial income and an upper-middle class lifestyle and continually makes snide comments about how a patient, a fellow staff member, or the dentist spends money. Comments to heed would be: "He bought that car only because he wanted to show how much money he earns;" or "I wouldn't be caught dead wearing that much jewelry;" or "$300 on a handbag? What a waste."

Gelle said that openly hating the way a person spends money creates in the embezzler's mind reasons embezzlement is OK: "Taking their money won't hurt them in the least bit. If they had the money, they'd only waste it."

Also suspect, according to Gelle, is the person who regularly carries a lot of cash or acts as the office's resident "banker," offering others small cash loans and advances, or cashing colleagues' personal or pay checks. Offering this service "justifies" why the person needs to carry so much cash. Gelle said much of the cash is probably stolen directly from patients' payments.

Another person to watch, Gelle wrote, is the person who adamantly resists any change in the present accounting system. He said this reaction especially rears itself if the change involves the replacement of an antiquated system with an easier, more efficient modern one.

Gelle said dentists should be suspicious about embezzlement if a new accounting system is implemented and there is a sharp increase in cash flow and profitability. It may be that the money is now going to the practice and not the embezzler.

Baby Teeth Used to Study Nuclear Fallout Effects

About 85,000 primary teeth collected between 1959 and 1970 to study the possible effects of nuclear weapons testing were discovered in spring 2001 in a Washington University, Saint Louis, basement. Researchers said the teeth could be used to correlate the bomb testing with health problems years later.

The teeth were collected by the greater Saint Louis Citizens Committee for Nuclear Information to determine if children were absorbing radioactive fallout from nuclear weapons testing by the United States and the Soviet Union in the 1950s. They were discovered when Washington University officials were cleaning out a school bunker where the teeth had been stored since the 1970s.

Researchers from the New York-based Radiation and Public Health Project have launched a project to find the owners of the teeth to determine if they have experienced health problems such as thyroid cancer that could be connected to fallout.

The Saint Louis Baby Tooth Survey collected teeth in the 1950s and 1960s, mostly within a 150-mile radius of Saint Louis. The Radiation and Public Health Project researchers would like to be contacted by anyone born and living in St. Louis from the late 1940s through the 1960s who may have submitted teeth to the study. If matched with any of the discovered teeth, respondents will be asked to complete a questionnaire about their health history.

The Radiation and Public Health Project can be reached at http://www.radiation.org/.

It Isn't Supposed to Be Like This

Dexterous hands that spent a lifetime perfecting skills that help our patients have beautiful smiles and healthy dentitions so that they can smile, and speak, and eat at joyous family gatherings, now examine and identify porcelain margins and skillfully crafted bridges in crushed skulls of patients who will never again smile or chew or celebrate -- all so that the deceased's family members can cry and grieve properly.

It Isn't Supposed to be Like This

Dentists who devoted their entire professional lives to enhancing their skills so as to improve the health of a small part of the human body, grapple with difficulty and try to understand the mentality of those who dedicate themselves to burning, exploding and crushing the life out of living, breathing humans.

It Really Isn't Supposed to Be Like This.

Reprinted with permission, New York State Dental Journal, October 2001

Dental Forensics Role in Disaster Response Lauded

Dental teamwork and electronic dental identification triage were essential to the success of Operation Noble Eagle, "one of the most comprehensive forensic investigations in U.S. history," the Armed Forces Institute of Pathology, an agency of the Department of Defense, said in a series of reports.

"All avenues of forensic investigation were explored and deployed with zero defects," said Navy Capt. Glenn N. Wagner, director of the institute. Officials offered new details on the institute's medicolegal response to the Sept. 11 terrorist attacks, which is code-named Operation Noble Eagle.

Officials credit a multidisciplinary effort in which dentists and dental forensics played important roles in the identification of victims of the terrorist attacks and said they hope to make it easier for dentists and other health professionals to "send digital information to us directly" in future disaster investigations.

CDA JOURNAL, VOL 30, Nº2

Why is Ergonomics an Issue in Dentistry?

RONALD S. MITO, DDS, AND KALLIE FERNANDEZ, BS

AUTHORS

Ronald S. Mito, DDS, FDS, RCS(Ed), contributing editor, is a professor and associate dean for clinical dental sciences at the University of California at Los Angeles School of Dentistry. He is also a member of the CDA Board of Trustees and a member of the ADA Council on Government Affairs.

Kallie Fernandez, BS, is a graduate of Loyola Marymount University and a pre-dental student.

There I was, a dentist in the prime of my career. I was driving my family to our annual summer vacation to Northern California when the first three digits of both hands started feeling profoundly numb. I thought it was driving fatigue resulting from the arms-up posture, so I would periodically lower my arms and shake my hands, and the numbness would dissipate. I would then alternate hands on the steering wheel. Yet, the numbness returned.

Then I started putting the picture together. During the previous few weeks, or was it months, I had begun to notice a very subtle but progressive onset of intermittent and sporadic paresthesias in the first few digits of my dominant hand, especially while holding a handpiece. Of course, at those times, I thought it was just excessive finger pressure; so I would take a brief break and rest my hand. I never appreciated the degree to which the situation was progressing, but the intensity was becoming so significant, I could no longer ignore it.

With both hands going numb, of course the usual mind speak occurred and I started to catastrophize, "Maybe you've got a C-spine problem with disc compression or something like that. It certainly can't be carpal tunnel in both wrists at the same time. Anyway, I'm too muscular to have weak wrists." That quickly progressed to, "What if I have to have neck surgery? Am I willing to go through with it?"

The symptoms continued and dominated my thinking during the vacation. I realized I was numb while holding the telephone. A quart of milk slipped right through my fingers, even though I thought I was grasping it tightly. My anxiety level was starting to build.

As soon as I returned home, my primary care physician put me into a cervical collar; and we started the diagnostic process. Bottom line -- I had positive results on the "gold standard" tests for bilateral carpal tunnel. In a way, it was a relief that it wasn't a C-spine problem, but it meant that I was facing bilateral wrist surgery and time away from practice; and I couldn't do my administrative duties, i.e., computer work, either.

I am now nearly two years down the road, post bilateral carpal tunnel releases and doing quite well. I am certainly not 100 percent, but I am back to work and being cautious.

It was my personal experiences with repetitive motion, work-related musculoskeletal disorders that motivated me to dedicate an issue of the *Journal of the*

California Dental Association to the topic of dental ergonomics.

As you may or may not know, the Occupational Safety and Health Administration created a federal ergonomics standard that was recently struck down by Congress. This was quite an onerous set of rules that would have dramatically affected many of us in every facet of practice. Over-regulation is a significant issue. However, the fact remains that work-related musculoskeletal disorders affect a significant portion of our profession.

According to OSHA, work-related musculoskeletal disorders occur when there is a mismatch between the physical requirements of the job and the physical capacity of the human body. Ergonomics, therefore, is the fitting of the job to the worker by designing the work and creating a work environment to help prevent work-related musculoskeletal disorders.1 In the same publication, OSHA goes on to state that in 1996 more than 647,000 American workers experienced work-related serious injuries due to overexertion or repetitive motion, resulting in 34 percent of the lost work days due to injuries and costing an estimated $15 billion to $20 billion in direct costs and $45 billion to $60 billion in indirect costs in 1995.

What is the relationship between the practice of dentistry and work-related musculoskeletal disorders? In 1995, Mangharam and McGlothan conducted a review of the literature, nearly 60 papers, and published a summary of their findings in the book Ergonomics and the Dental Care Worker. According to their review, the literature supports the relationship between working as a dental professional and the incidence of work-related musculoskeletal disorders and psychological stress.2 More recently, Hamann and colleagues published a study on the prevalence of carpal tunnel syndrome and median mononeuropathy among dentists. This study found that dentists reported hand and finger symptoms at a higher rate than the general population. However, when tested by electrodiagnostic criteria, the actual incidence of carpal tunnel syndrome was similar to that of the general population. What does this really mean? Hamann and colleagues state that the presence of symptoms increases the ultimate risk for carpal tunnel syndrome. Thus, the high rate of symptoms associated with dentistry supports the need for education regarding risk factors and early recognition of these symptoms to potentially enhance disease management.3

In 1997, Murphy published an article correlating the common risk factors in the general public to the practice of dentistry. These include constrained and fixed posture (sitting), awkward postures (neck/shoulder/wrist postures), exertion of force (extraction of teeth), repetitive motions (scaling), and duration of force (injection of anesthetic/scaling). Murphy also relates these risk factors to "ergonomic causes" -- work station design (operatory), tool design, work object (patient), work techniques, work organization (case load), and work environment (lighting).4

While the threat of regulatory intervention has been reduced for now, the prevalence of work-related musculoskeletal disorders in the dental workplace should generate concern among practitioners/employers to be knowledgeable and vigilant to protect themselves and their staffs. The purpose of this Journal issue is to provide the reader with current, useful information on work-related musculoskeletal disorders. The Laderas and Felsenfeld article provides a regulatory review and update. The Rucker study addresses the incidence and some of the background for work-related musculoskeletal disorders as related to postural and positional profiles of dentists. Jones and colleagues present contemporary diagnostic and treatment modalities for hand and wrist symptoms. Chang addresses the ergonomic impact of surgical telescopes and coaxial lighting. And lastly, Yoser presents preventive measures that we can all use on a daily basis.

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CDA JOURNAL, VOL 30, Nº2

Ergonomics and the Dental Office: An Overview and Consideration of Regulatory Influences

SANDY LADERAS, RDAEF, CDA, MA, AND ALAN L. FELSENFELD, MA, DDS

ABSTRACT Nearly 2 million workers suffer from musculoskeletal disorders each year. These problems are caused by repetitive, awkward, or stressful motions. Dental health care workers are susceptible to these types of injuries. This article will discuss state and federal programs to control job-related injuries and relate the regulations to dental practice.

AUTHORS

Sandy Laderas, RDAEF, CDA, MA, is the supervisor of the Dental Auxiliary Utilization Program and coordinator of infection control at the University of California at Los Angeles School of Dentistry

Alan L. Felsenfeld, MA, DDS, is an adjunct professor of oral and maxillofacial surgery at the UCLA School of Dentistry and chairman of the Council on Dental Research and Developments for the California Dental Association

Each year, according to estimates from the Bureau of Labor Statistics, nearly 2 million workers suffer from work-related conditions known as musculoskeletal disorders. These problems are caused by repetitive, awkward, or stressful motions.1 Prime examples of these injuries include carpal tunnel syndrome, tendonitis, and neck or back problems. While dental health care workers represent only a small part of the total workforce, they are susceptible to these types of injuries as a consequence of occupational stresses placed on their bodies. This article will discuss state and federal programs to control job-related injuries and relate the regulations to dental practice.

California Regulations

Title 8 of the California Code of Regulations was amended in 1997 to include Section 5110 on repetitive motion injuries. The objective of these amendments was to reduce disorders for workers whose jobs involve repetitive motion, force, awkward postures, contact stress, and vibration. While these regulations were controversial when introduced, they are in effect and represent California law.

This law provides a definition that is applicable to any job, process, or application where a repetitive motion injury has occurred to more than one employee. Additionally, the following criteria need to be present:

- The injuries were caused predominantly by a work-related incident.

- The injured employees were performing the same type of job.
- The injuries were diagnosed objectively by a physician.
- The injuries were reported to the employer within the previous 12 months but not before the date of enactment of the regulation.2

When the above criteria for repetitive motion injuries are identified, the employer is required to develop a program designed to minimize these injuries. This program must include a worksite evaluation for repetitive motion injury exposures and a plan to correct worksites that represent a risk for employee injury. This plan might include redesigning or refitting workstations as well as protecting employees through job reclassifications or responsibilities.

Additionally, employers are responsible for providing training of employees regarding repetitive motion injuries. This training must include:

- A description of the employer program;
- Identification of exposures in the workplace that have resulted in repetitive motion injuries;
- The symptoms and consequences of repetitive motion injuries;
- The importance of reporting the symptoms to the employer; and
- Methods used by the employer to minimize repetitive motion injuries in the workplace.

Subsequent to the enactment of this regulation, the California Department of Industrial Relations, Division of Labor Statistics and Research, stated that job-related nonfatal injury/illness rates in 1999 decreased from previous years. A record low of 6.3 workers injured out of every 100 was obtained, while employment increased 3 percent. This represented a decrease from 6.7 per 100 workers in 1998. The decrease was attributed to the California Occupational Safety and Health Administration inspection program focus on agriculture and construction, the highest areas of injury in the past. Of the nonfatal occupational illnesses reported, 56 percent were disorders associated with repeated trauma.3 The effects on dentistry appear to be minimal.

Federal Legislation

At the federal level, OSHA published ergonomic standards that were to be effective Jan. 16, 2001, and implemented no later than Oct. 14, 2001. The original ergonomic standard was written to require employers to adopt the principle of ergonomics -- fitting the job to the worker through adjusting a workstation, rotating between jobs, or using mechanical assistance.4 These standards required employers to inform all employees regarding musculoskeletal disorders in the workplace. The information was to include signs and symptoms, the importance of reporting injuries, risks of the job for musculoskeletal disorders, and a description of the OSHA ergonomics program standard.5 Congress, recognizing that there was much uncertainty as to the compliance requirements of the regulations, forced its withdrawal in March 2001. However, the Bush administration held public hearings during the summer of 2001 as to whether and how to provide regulation for work-related repetitive motion injuries. It is the intention of federal OSHA to base new regulations on injury prevention, sound science, incentives, program flexibility, cost feasibility, and program clarity.

Shortly before this issue was to be printed, the Department of Labor released a statement saying that "in the wake of the Sept. 11, 2001, event, the Department will temporarily postpone the announcement of a plan of action on ergonomics." Additional announcements were scheduled for the fall.6

The Dental Office

What is the relationship of ergonomics to dental offices? The concept of ergonomics in dentistry is not of recent onset. In the late 1950s, Eccles and Powell wrote one of the first journal articles pertaining to dental ergonomics.7 By the 1960s, Kilpatrick and others began to identify postural and procedural rules for sit-down dentistry.7 Ergonomic education in the dental schools from the 1970s to the present included such concepts and practices as performance logic, four-handed dentistry, human factors engineering, and dento-ergonomics. Considering that most dental care is provided while the team is seated, seated postures play a key part to spinal balance. In a recent article, it is noted that dentists have "experienced less varicosities of the legs, but more breakdowns of the upper back and extremities."8

Improved technology has had a significant impact on the way dentistry is practiced today. However, technological advances in dentistry may have a deleterious effect on providers relative to musculoskeletal disorders. Even the physical placement or location of equipment and use patterns can affect the way dental professionals work.

The risk of having a musculoskeletal injury or work-related disorder may be high in dental practice. Sit-down dentistry is not without potential harm to the dentist or the staff if equipment or other constraints create postural problems. Dental school curricula may not be able to spend a significant amount of time in the teaching of ergonomically correct work habits.

The Proactive Approach

The California Dental Association has learned that a proactive approach to internal evaluation may minimize exogenous regulation in the dental office. Consideration should be given to performing an ergonomic assessment of one's dental practice. If there have been complaints from the staff or if the dentist or staff is feeling the stress and strain of practice more intensely than in the past, there may be potential for repetitive motion disorders. In an effort to prevent musculoskeletal disorders, it may be wise for the dentist to meet with his or her staff or add a discussion to the office meeting agenda. The dentist should consider asking questions such as these developed by Cal/OSHA:

- Have there been musculoskeletal injuries or complaints in the practice?
- Has the scheduling, pace, organization or work activity changed?
- Have staffing levels decreased?
- Have new job tasks or equipment created any operating inefficiencies?
- Is there an effective procedure for problem evaluation and correction?
- Is any additional training needed? 9

Conclusion

At present in California, dental office ergonomic regulation is based on practices that have a history of repetitive motion injuries. Federal OSHA standards, while not in effect at this time, potentially will be slightly more stringent in the proposed approach mandating all offices to develop plans to protect employees. It is only rational that dental providers would like to minimize injuries to their employees and themselves from repetitive motion injuries. It makes sense that all dental practices should consider the ergonomic implications of their offices.

The dentist should determine his or her needs for employee and self-protection and develop a plan of action. He or she should perform an annual review to keep the plan current. Careful preparation and prevention of repetitive motion injuries can save significant amounts of lost time as a result of employee absenteeism. Likewise, it can save the dentist from injuries that could jeopardize his or her career.

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To request a printed copy of this article, please contact/ Sandy Laderas, RDAEF, CDA, MA, UCLA School of Dentistry, Center for the Health Sciences, Room 53-038, Los Angeles, CA 90095-1668.

CDA JOURNAL, VOL 30, Nº2

Ergonomic Risk Factors Associated with Clinical Dentistry

LANCE M. RUCKER, DDS, AND SUSANNE SUNELL, BA, DIP. DH, MA

ABSTRACT Ergonomics has formed an integral aspect of dental education at the University of British Columbia since the early 1980s. However, studies continued to indicate that dentists are at risk for developing musculoskeletal problems. This provided the impetus for a study of the risk factors associated with these problems. The data analyzed from 421 survey respondents in British Columbia indicates that indeed dentists are experiencing musculoskeletal pain and discomfort. However, it also suggests that dentists can recognize and identify their own postures, practicing positions, and the equipment usage patterns that are associated with increased risks of experiencing musculoskeletal pain and discomfort. Such recognition is the first critical step to avoiding or neutralizing ergonomic habits and work environment layouts that might otherwise unnecessarily shorten professional clinical careers.

AUTHORS

Lance M. Rucker, DDS, is the director of clinical simulation and an associate professor and chairman of the Division of Operative Dentistry at the University of British Columbia.

Susanne Sunell, BA, Dip. DH, MA, is with the Department of Dental Hygiene at Vancouver Community College and a candidate for a doctorate in education.

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As increasingly sophisticated dental equipment has entered the marketplace, the potential for improving the occupational health of dental practitioners has expanded. Despite this, dental practitioners continue to identify chronic back, neck and shoulder pain as occupational ailments,1 often associated with early retirement from the profession.2 Students continue to develop musculoskeletal disorders, even within educational programs, and recent graduates indicate that they are adjusting practice schedules to accommodate their cumulative trauma disorders.3,4 Despite the evidence of musculoskeletal disorders in dentistry, surprisingly little research has been conducted in this area.

Furthermore, a glance at most photographs depicting practitioners at work in articles and advertisements in professional and popular media betray a continued professional tolerance and acceptance of physically imbalanced, compromised postures and positions used in the performance of clinical dentistry. Seeing such representations, members of the rehabilitation professions (including physiotherapists, physiatrists, occupational therapists, massage therapists, chiropractors, etc.) often erroneously conclude that the daily practice of dentistry necessarily involves frequent, ongoing mechanical compromises to job performance. When physical breakdowns occur, many of these rehabilitation specialists will declare that the dentist is unable to continue clinical work because of such presumptions about the innately health-compromising nature of dental practice.

The literature indicates that both dentists and hygienists are experiencing back, neck and shoulder pain and are, in many cases, attributing these problems to the provision of clinical care.5-7 Studies in median nerve sensitivity and cumulative trauma disorders of the median nerve (such as carpal tunnel syndrome) also identify dental practitioners as being at risk.8,9 Consistent reports of work-related and work-impairing injuries of dentists and dental hygienists indicate an average incidence of more than 60 percent of workers who have experienced work loss during the preceding year related to musculoskeletal pain.10-12

Many factors appear to be instrumental in contributing to musculoskeletal disorders, including medical, occupational, and/or lifestyle factors that are conducive to these disorders. The occupational patterns that appear to be influential include excessive use of small muscles, repetitive motions, tight grips, fixed working positions, raised arms, limited movements and long-term static load on muscles.13 The exact nature of the relationship between these factors and musculoskeletal problems is unclear.14,15

To explore the issues of clinical ergonomics, beginning in the early 1980s a team of University of British Columbia researchers investigated "performance logic," a problem-solving model based on individualized positioning.16 The performance logic approach begins with a proprioceptive exercise to determine the individual operator's preferred posture and positions for physical and visual control of fine motor activity. In effect, it is based upon the clinician's individual musculoskeletal requirements, anatomy and physiology, using self-derivational approaches that attempt to neutralize the limitations that might have been imposed by specific equipment and by habituation from prior psychomotor experience.

The performance logic model has been used to integrate clinical ergonomics education throughout the undergraduate dental curriculum at the University of British Columbia since 1983 and was further developed with the addition of surgical magnification systems for preclinical and clinical practice in 1990.17 When an operator's visual acuity is not matched to optimal, comfortable musculoskeletal positioning, the integration of carefully selected surgical magnification systems into the clinical armamentarium has been found to be especially effective in supporting the operator's preferred angle of vision while maintaining the optimal musculoskeletal operating posture.18

The current study is an attempt to gain an understanding of the health status of British Columbia dentists regarding the types of musculoskeletal discomfort and pain they are experiencing, and what impact this is having on their professional lives.

Methods

In a new dental clinical ergonomic study, 421 responses (representing a 43 percent response rate) were received from surveys sent to all dentists practicing in British Columbia who had graduated between the years 1987 and 1996, regardless of the dental school attended. Almost half (48 percent) of the respondents were graduates of the University of British Columbia Faculty of Dentistry and thereby constituted a study group for the effects of integrated clinical ergonomics education during their entire undergraduate training program. A subset of this study group (since 1990) had also utilized surgical magnification. These were telescopes that supported optimized declination angles and working distances during all phases of the dentists' preclinical and clinical training.

The surveys consisted of a combination of open-ended and closed-ended questions asking the respondents to rate items and to address issues important to the understanding of their work patterns, symptoms, and identified (or suspected) health risk factors. The questionnaires asked respondents for information about their practice ergonomics, practice management issues, lifestyle, and perceived control of their work environment, as well as questions about specific musculoskeletal symptoms.

The questionnaire data was analyzed through descriptive and inferential statistics. The analysis included comparisons of groups (and subgroups) with respect to a number of variables including symptoms, practice patterns, equipment characteristics and psychosocial factors. To calculate measures of association between the respondent attributes, Spearman rank correlation coefficients (rS) were used when the data was ordinal and the Pearson chi-squared statistic (c 2) when the data was nominal. An alpha (p value) of 0.05 was applied to these tests.

The data is based entirely on the perceptions and self-reports of dentists as to their practices, their equipment configurations, their posture and positioning profiles, their medical histories, their personal exercise habits, and their musculoskeletal symptoms. The questionnaire required about 45 minutes to complete.

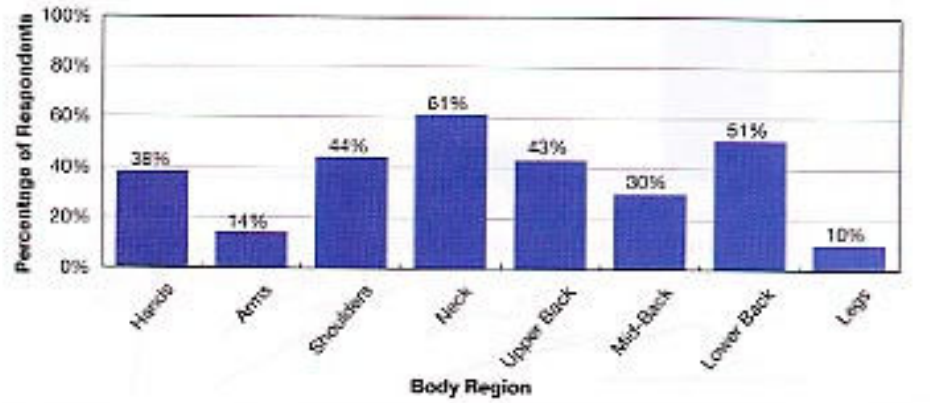
Results

About two-thirds of the 421 dentist respondents were male (67 percent). Among the dentists, the vast majority were general practitioners (91 percent). All graduated between 1986 and 1997. Two-thirds (66 percent) had been in practice for five or more years. Almost all (94 percent) commonly practiced seven or more hours each day, and 86 percent practiced four or more days each week. Eighty-one percent of the dentists practice more than 40 weeks each year. Not surprisingly, given the target graduation period, the respondents were fairly young. Seventy percent were 30 to 39 years of age, and only 11 percent were older than 40. If anything, this would suggest a fairly healthy study population. This suggestion is well-supported by the

CDA JOURNAL, VOL 30, Nº2

Table 1.

Respondents Experiencing Work-Related Discomfort or Pain During the Past Year



respondents' subjective ratings (on a scale of 1 to 5) of overall health: 87 percent claimed good to excellent overall health, 12 percent average overall health, and only 1 percent below average overall health.

In spite of this overall positive subjective bill of health, in the section that addresses musculoskeletal health status by specific anatomical areas, the respondents (dentists) identified a multitude of localized pains that which they subjectively perceived as work-related (**Table 1**).

Nearly one in 10 dentists (9 percent) experienced episodes of hand pain, which they perceived as work-related, on at least a weekly basis. Nearly one in five dentists (18 percent) experienced episodes of shoulder pain on at least a weekly basis. Nearly one in four (24 percent) dentists experienced episodes of neck pain on at least a weekly basis. Nearly one in five dentists (19 percent) experienced episodes of upper back pain on at least a weekly basis. Thirteen percent of dentists experienced episodes of mid-back pain more often than once a month. More than one in six dentists (17 percent) experienced episodes of lower back pain on at least a weekly basis.

One in three dentists (34 percent) attributed their musculoskeletal symptoms entirely to their clinical work. Another 54 percent attributed their musculoskeletal symptoms partially to their clinical work, and only 7 percent felt that their symptoms were related solely to factors other than their clinical work.

As to the outcomes of their work-related problems, only 13 dentists (4 percent of the respondents) had decreased their number of working days per week. Nineteen percent of the dentists experienced decreased ability to perform recreational activities, and 14 percent showed decreased abilities to perform activities at home. Other sequelae included painful performance of recreational activities (14 percent) and painful performance of activities at home (13 percent). Seven percent of practitioners purchased specialized equipment to deal with their work-related problems, but only 5 percent actually redesigned their operatories. Three out of five respondents (60 percent) reported that they just "lived with the pain (tolerated it)." A total of 13 dentists (4 percent of the respondents) recorded the loss of a total of 99 work days during the previous 12 months as a result of their musculoskeletal symptoms. Only one in three dentists (33 percent) indicated that they have not experienced any work-related problems.

Equipment and Usage Patterns

For developing the following equipment inventory, the authors have chosen to characterize usage of specified equipment for more than half of the time (in clinical practice) as a significant part of the clinician's working profile. Almost all dentists use adjustable operating lights (91 percent) and operating stools whose height can be adjusted in 10 seconds or less (83 percent) and which move easily across the floor (95 percent). In 7 percent of the operatories, there is carpeting under the operators' stools. Few use arm rests on the operating stools (3 percent), and only 37 percent use lumbar supports. Sixty-five percent work in equipment settings where they can position themselves freely around the dental chair.

Most dentists position their operating stools so that their hips are at the same level as their knees (76 percent) or slightly higher than their knees (15 percent). Only 1 percent commonly stand when they work.

Seventy-eight percent use handpieces for more than half of their practicing time, and most (91 percent) use intraoral mirrors most of the time. Four-handed dentistry involving a chairside dental assistant is the usual practice mode for 89 percent of dentists.

For the performance of maxillary (upper arch) treatment, 85 percent of dentists position the patient fully supine with the maxillary plane approximately vertical (Table B) Eighty-three percent position the operatory light source at increased angles toward the patient's feet (Table C).

Among the respondents, 59 percent use surgical magnification systems of some kind. Of those using such systems, most have been using them for more than three years.

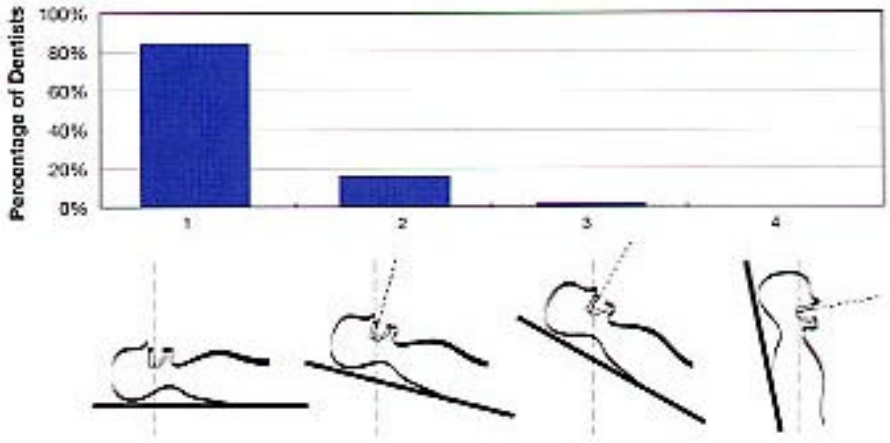
Posture and Positioning Profiles

Sixty-three percent of the dentists position their hands at about elbow height during clinical operation. Some 21 percent operate with hands at heart

CDA JOURNAL, VOL 30, Nº2

Table 2.

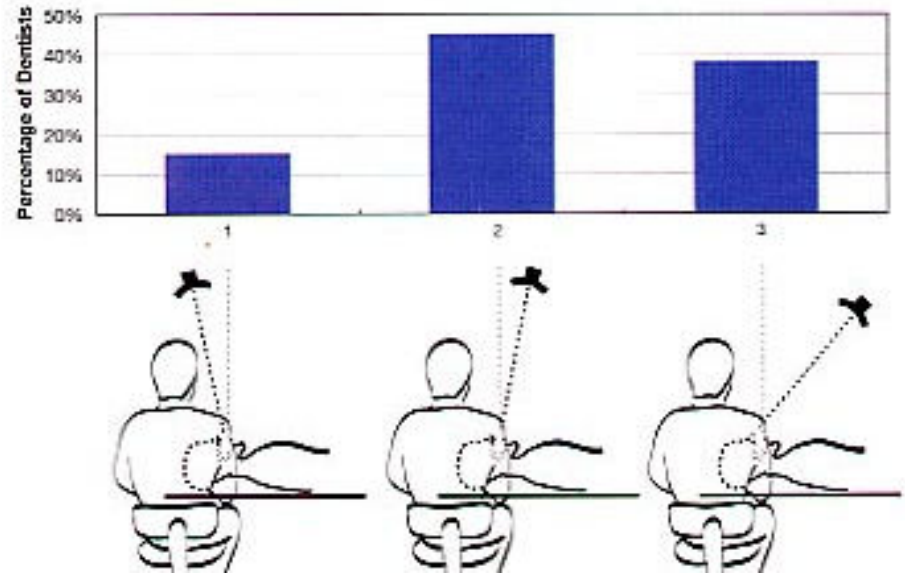
Patient Position for Maxillary Treatment



Position of patient

Table 3.

Operatory Light Source Position for Maxillary Treatment



Position of light

height, and only 14 percent operate with hands below the elbows.

Only about a third (32 percent) position themselves and arrange their access to their work so that they do not commonly raise their dominant elbows from a relaxed position at their sides. Sixty-six percent report that they raise the dominant elbow approximately 45 degrees for the majority of their work, and a few (2 percent) even as much as 90 degrees. Their data profile for the nondominant arm is nearly the same (36 percent, 57 percent, and 6 percent, respectively).

When positioning themselves around the head of the patient, only 38 percent of dentists never use the 7 to 8:30 o'clock range, 72 percent never use the 1:30 to 3 o'clock range, and 88 percent never use the 3:30 to 5 o'clock range.

Fifty-nine percent of the dentists keep their legs beneath the patient chair during treatment. Only 4 percent operate with their legs at the side of the patient chair (which requires a torso twist to access the patient's oral cavity), and 33 percent operate with their legs split at the head of the patient chair (which limits their ability to shift positions freely in the clock positions for optimal access to the oral cavity).

Only 9 percent indicated that they never tip their shoulders to the side (**Figure 1**) during practice, and 16 percent reported that they avoid rotation of their torsos (trunks) relative to their lower body during patient treatment.

Most (88 percent) use intraoral finger rests for instrument stabilization, and 25 percent usually use extraoral hand rests on the patient's face to stabilize further and/or to offset the fatigue of supporting the forearms during fine motor manipulations required for intraoral treatment.

Correlations of Postural and Positional Profiles with Musculoskeletal Symptoms

The correlations of association of musculoskeletal symptoms with various aspects of the practice and behaviors of

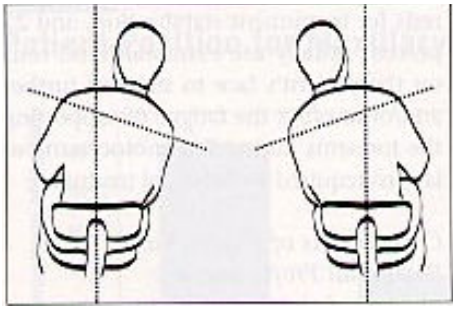


Figure 1. Tipped torso.

dentists are shown below. In the interest of simplicity and clarity, only the p values (inversely reflective of the strength of the correlation) are indicated for all associations. The lower the p value, the stronger the association. Only statistically significant variables of .05 or less are recorded.

Equipment and Usage Patterns

- Increased time with the clinician's legs directly beneath the patient chair is associated with decreased reports of upper back pain (p=.034). Dentists whose operating lights are positioned farther away from their sightlines (towards the patient's feet) for maxillary work were more likely to experience lower back pain (p=.008).
- Use of surgical magnification is associated with a decrease of pain in the lower back (p=.034).
- Increased use of lumbar supports on operating stools is associated with decreased reports of leg pain (p=.007).

Posture and Positioning Profiles

The following significant associations were found in the postural and positioning profiles.

- The more likely clinicians are to raise the dominant elbow while they work, the more likely they are to experience musculoskeletal symptoms in many regions of the body. Dentists who utilize such positions more than 50 percent of the time are more likely to experience pain in the hands (p=.001), shoulders (p=.007), neck (p=.001), and upper back (p=.003).
- Furthermore, the more likely dentists are to raise the nondominant elbow while they work, the more likely they are to experience musculoskeletal syndromes in many regions of the body: in the hands (p=.037), arms (p=.034), neck (p=.005), and upper back (p=.004).
- The greater the percentage of time dentists spend practicing with their shoulders tipped to the side, the more likely they are to experience pain in the hands (p=.017), arms (p=.026), shoulders (p=.001), neck (p=.001), upper back (p<.001), and lower back (p=.006).
- The greater the percentage of time dentists spend practicing with their torsos (trunks) rotated to any discernible degree, the more likely they are to experience pain in the hands (p=.047), shoulders (p=.003), neck (p=.003), upper back (p<.001), and lower back (p<.001).
- Dentists who spent a greater proportion of their practice working with an assistant (4-handed) were less likely to experience shoulder pain (p=.041).
- Dentists who use the 7 to 8:30 o'clock range a greater percentage of the time in practice reported increased pain in their hands (p=.044), arms (p=.009), and upper backs (p=.050). Dentists who use the 3:30 to 5 o'clock range a greater percentage of the time in practice reported increased pain in their arms (p=.009), upper backs (p=.048), and legs (p=.039).

Clinical Ergonomics Education

The statistical comparison for the effects of integrated clinical ergonomics education comparing University of British Columbia graduates to the control group of non-University of British Columbia graduates confirms that the former group is less likely to have lower back pain (p=.05) than the latter.

Furthermore, the University of British Columbia graduates are indeed practicing the performance logic posture and positioning profiles they were taught during their clinical ergonomics training at University of British Columbia. That is, the majority of the performance logic posture and positioning elements are significantly characteristic of the practice habits and styles of the University of British Columbia graduates. The data also identifies that many key ergonomic posture and positioning profiles elements are not being practiced by those dentists (non-University of British Columbia) whose dental school curricula did not include performance logic experience.

Discussion

In the dental health field, there has been much attention directed toward carpal tunnel syndrome as a focus of primary concern with regard to work-related musculoskeletal symptoms. The current study has provided information that has directed attention to other important areas as well. Dentists continue to be at risk for a variety of musculoskeletal symptoms. However, there appear to be specific equipment, postural, and positioning variables that clinicians can adjust to decrease their risks.

The correlations of increased musculoskeletal symptoms with use of the certain positions around the patient chair (7 to 8:30, and 3:30 to 5) may be related to the effects of the torso-twisting and elbow-raising compromises identified in the same posture and positioning profiles section. This is not surprising, given the distorted body postures often associated with the use of such positions around the patient chair.

The compromising effects of operatory light positioning towards the patient's feet are probably the result of violations of the physics of light lines and sight lines, which is especially dramatized by the use of an intraoral mirror. This issue may be challenged by some traditional dental assistant programs in which the more classic but erroneous directions found in textbook references train assistants to

use direct lighting of the maxilla (with the light positioned away from the sightline of the dentist) for treatment on that arch. Although direct maxillary lighting may improve unshadowed viewing from the perspective of the chairside assistant, it virtually guarantees a compromised view for the dentist and results in the dentist tipping the head and torso to bring the eye line closer to the light line, in an attempt to see better.

The correlation of increased use of surgical magnification with decreased risks for experiencing low back pain should be considered in the context that most of the users of surgical magnification in the study were University of British Columbia graduates with systems that allowed for appropriate declination angles for their optimal working postures. Most systems in use by dentists today are limited in their abilities to produce optimal declination angles,17,19 and the reductions of musculoskeletal symptoms for such users may not be the same as those generated in the University of British Columbia study.

To be sure, there are many things beyond postural and equipment-related ergonomic high-risk factors that are important elements in the dental professionals' exposure to increased musculoskeletal symptoms. For example, the study also confirmed health factors such increasing age, smoking, and certain pre-existing medical conditions (such as diagnoses of spinal curvature or certain eye problems) as co-factors in higher risk.

Likewise there are health and fitness factors that seem to be associated with decreased risk of musculoskeletal syndromes among dentists, such as increased frequency of moderately paced physical activities and increased frequency of strengthening exercises. Other findings of the study confirm that certain psychosocial and environmental factors are associated with increased risk of musculoskeletal symptoms for dentists, including less control over day-to-day workload, impairment of opportunities to provide input at work, discomfort in asking co-workers for assistance, and compromised quality of air or temperature in the work environment.

Some practitioners may not have understood the subtle differences among the survey diagrams; they may not have had the awareness and/or ergonomic knowledge to provide accurate data. The questionnaire required about 45 minutes to complete; this time commitment may have affected the response rate. An argument is also commonly made that people with musculoskeletal problems would be more likely than asymptomatic people to respond to a voluntary survey, particularly a lengthy one. These are all possible limitations of our study. However, the incidence of musculoskeletal symptoms reported by the survey respondents closely matches the results of other studies of oral health practitioner populations in other parts of the world.

Self-recognition by a clinician of any one of the signs of high-risk ergonomic profiles might be a cause for alarm, but recognition of multiple factors should be especially concerning. One or more of these signs that are accompanied by symptoms of pain or discomfort in any of the body regions identified in the study are redoubled cause for concern. Just as certain individuals have smoked several packs of cigarettes per day for many decades without having cancer, so it is not unlikely that certain individual clinicians might sustain the self-abuse of the identified high-risk ergonomic profiles and still continue practice without clinically compromising repetitive strain injuries. However, the risks are real and the posture and positing profiles are modifiable and preventable. Most of the negative (high-risk) ergonomic factors associated with musculoskeletal symptoms can be reduced, modified, or eliminated from practice, and most of the positive factors are elements that can be learned, encouraged, and/or acquired.

Appropriate educational measures undertaken as part of the initial basic training programs of dentists can help reduce the high-risk clinical equipment usage factors and posture and positioning profile factors that are associated with increased risks of musculoskeletal symptoms for dentists. What is not yet known is the degree to which such education has similar success in postgraduate and continuing educational contexts. However, there is a need to increase clinician awareness of the factors that are associated with increased musculoskeletal symptoms, so that performer-based, equipment-based, and/or practice management-based programs might be introduced for intervention where feasible.

Given that this study has relied on clinicians' personal subjective appraisals of practice characteristics, it becomes somewhat easier to alert the at-risk population than it would be if the observations required external monitoring. A self-assessment tool is currently being prepared that can increase clinician self-awareness of identified risk factors for the office and its personnel, and that will point toward solutions to specific identified problems.

Coupling of the posture and positioning profiles/musculoskeletal symptom associations increases the recognition of alternatives related to specific behavioral changes and might help to increase motivation of the dentist to change to healthier practice patterns. What has been perceived more often than not as a hopeless, unavoidable syndrome associated with the dental health occupations now becomes related to equipment variables, to specific behaviors, and to observed "postures and positions associated with the way I do my work." Once we invite and allow for potential variation in work patterns, clinicians who are in pain can begin to make some changes and to see the results of those changes.

By and large, dentists "put up with" their pain because they do not know specifically what has caused it, much

CDA JOURNAL, VOL 30, Nº2

less what to do about it. When many of their professional colleagues have similar musculoskeletal symptoms, the logical conclusion is that such symptoms and their sequelae are an unavoidable part of the work of the profession. So they continue to work for their equipment more often than not (rather than making their equipment work for them), and the cycle continues.

The profession might do well to encourage basic, seminar-type educational programs in clinical ergonomics directed toward the recognition, interception, and reduction of identified high-risk patterns of work and lifestyle for all members of the dental team. To date, continuing education programs in dental clinical ergonomics have focused largely on reducing nonpractice risk factors and on palliative therapy for clinicians who have been injured. Few clinicians with high-risk profiles who are not yet symptomatic have either realized their risk level or been motivated to deal with the problems. The challenge for the profession is to raise the awareness level of the asymptomatic group, making real prevention a possibility.

Research initiatives allow us to define and refine ergonomic competencies for the practice of dentistry. This in turn allows professional associations to establish practice standard guidelines, ergonomic accreditation guidelines for educational institutions, operatory layout designs, and equipment integration guidelines for manufacturers. National and international standards bodies (such as the International Organization for Standardization [ISO] and Canadian Standards Association) need evidence to drive the specification of designs and manufacturing tolerances that support optimal ergonomics in the workplace.

The findings of the British Columbia study suggest the value of reviewing ergonomic standards for operatory equipment in dental practices. Indeed, it is possible to define and test certain minimum standards of equipment and layouts to be provided in dental offices to minimize the exposure of dentists to work-related musculoskeletal symptoms. Similarly, there is enough information to begin to refine guidelines for utilization of dental operatories to minimize the exposure of all dental operatory personnel to work-related musculoskeletal symptoms.

Summary

While dentists continue to be at risk for developing musculoskeletal symptoms, the findings of this study suggest several distinct and identifiable clinical equipment usage factors and posture and positioning profile factors that are associated with increased risk of musculoskeletal symptoms for dentists, including the following:

- Torso twist;

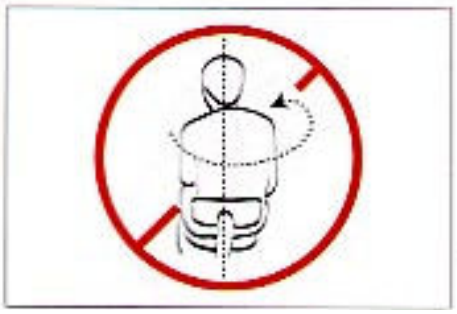


Figure 2. Torso twist.

Figure 3. Tipped shoulders

Figure 4. Elbow (either dominant, nondominant, or both) raised during operation.

Figure 5. Operatory light positioned away from the clinician's sight line for maxillary treatment.

Figure 6. Operating with hands close to face.

Figure 7. Increased time practicing in the 7 to 3:30 to 5 o'clock positions.

Figure 8. Both dominant and non-dominant elbows resting at the clinician's side during operation.

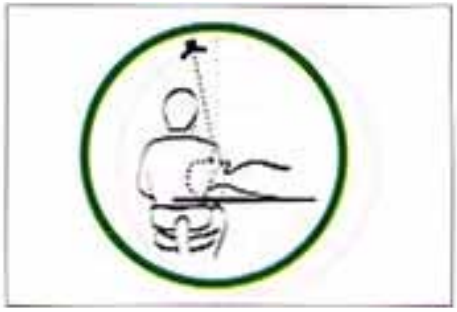


Figure 9. Operatory light positioned close to the clinician's sight line for maxillary treatment.

Figure 10. Equipment that is designed and utilized so as to permit the legs of the clinician to be directly under the patient chair during treatment.

- Tipped shoulders;
- Elbow (either dominant, nondominant, or both) raised during operation;
- Operatory light positioned away from the clinician's sight line for maxillary treatment;
- Operating with hands close to face; and
- Increased time practicing in the 7 to 8:30 and 3:30 to 5 o'clock positions.
- Certain clinical equipment usage and posture and positioning profile elements are associated with decreased risk of musculoskeletal symptoms for dentists:
- Use of surgical magnification;
- Utilization of four-handed (assisted) delivery;
- Both dominant and nondominant elbows resting at the clinician's sides during operation;
- Operatory light positioned close to the clinician's sight line for maxillary treatment; and
- Equipment that is designed and utilized so as to permit the legs of the clinician to be directly under the patient chair during treatment.

The findings of this study suggest that there is a sufficient information base to begin to refine guidelines for utilization of dental operatories to minimize dentists' work-related musculoskeletal symptoms. It is time dentistry focused its attention on these critical areas to support the health of current practitioners and those of the future.

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To request a printed copy of this article, please contact/ Lance M. Rucker, DDS, Faculty of Dentistry, The University of British Columbia, 2199 Wesbrook Mall
Vancouver, BC V6T 1Z3, CANADA

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Repetitive Motion Hand Disorders

Douglas H.C.L. Chin, MD, and Neil F. Jones, MD

ABSTRACT The clinical management of cumulative trauma disorder is based upon the identification and treatment of individual component pathologies and, frequently, referral to a knowledgeable occupational therapist with an understanding of ergonomic behavioral, postural, and workspace modification. Most commonly, these individual pathologic entities are carpal tunnel syndrome, cubital tunnel syndrome, trigger finger, and De Quervain's tenosynovitis. In this article, the anatomy, diagnosis, and treatment of each of these disorders will be considered separately. In addition, since these clinical entities are often use-related, special attention should be directed toward biomechanical and ergonomic considerations.

Authors

Douglas H.C.L. Chin, MD, is a clinical instructor at Alta Bates Summit Medical Center in Oakland, Calif.

Neil F. Jones, MD, is a professor in the Department of Orthopaedic Surgery and Division of Plastic and Reconstructive Surgery at the University of California at Los Angeles.

The various names given to the clinical disorder known as cumulative trauma disorder, repetitive strain injury, repetitive motion injury, overuse syndrome, work-related musculoskeletal syndrome, and repetitive stress injury reflects the poor understanding of the pathophysiology of this entity. The currently favored designation is cumulative trauma disorder, but even this name betrays a great misunderstanding of the pathophysiologic influences underlying the disorder. Contrary to the implications of its name, cumulative trauma disorder is typically characterized by a lack of antecedent trauma. Even the notion of an additive effect of many minor but repetitive "microinjuries" as a result of repetitive motions is unsubstantiated and probably false. Conversely, cumulative trauma disorder of the upper extremity is characteristically associated with a history of repetitive stereotyped behaviors that require prolonged static posturing of the upper extremity, not repetitive traumas. Moderate or high-energy repetitive maneuvers are notably absent from the typical history. Interestingly, symptoms often relate not to the tendon and muscle groups involved in repetitive motions, but to the stabilizing or antagonistic tendon and muscle groups used to position and stabilize the extremity in space during the repetitive motion.

Clinically, the symptomatology of cumulative trauma disorder is as ill-defined as its pathophysiology. There are no established criteria for determining its diagnosis. Clinically, most hand surgeons will designate the term cumulative trauma disorder to an ill-defined, inconsistent, widely variable but often debilitating constellation of weakness, paresthesias, pain, and tenderness of the upper extremity in the presence of a significant history of repetitive stereotyped upper extremity activity. Hand surgeons attempt to reduce this perplexing array of symptoms into a compilation of well-understood clinical entities, such

as carpal tunnel syndrome and trigger finger, for example. This tendency to reduce the complex and poorly understood aggregate of cumulative trauma disorder into individual well-understood component entities has some practical clinical importance, because many of the symptoms of cumulative trauma disorder are effectively treated and often dramatically improved using traditional surgical procedures directed at the component clinical entity. The characteristic of cumulative trauma disorder, however, is a tendency toward either recurrent problems or the development of additional symptoms following treatment for one entity. Therefore, long-term relief is possibly best accomplished through thoughtful modifications in upper extremity use habits or careful redesign of workplace conditions.

As poorly understood as cumulative trauma disorder may be pathophysiologically, it is clear clinically that it tends to be over diagnosed. Properly applied, cumulative trauma disorder should be designated when a constellation of refractory or recurrent symptoms are present in association with a history of repetitive or prolonged stereotyped use, or when such symptoms and history are associated with the development of additional symptoms following treatment. Isolated clinical entities such as carpal tunnel syndrome do not alone constitute cumulative trauma disorder, even when associated with a significant history of repetitive stereotyped behavior, such as keyboard use or dental handpiece use.

For the hand surgeon, the clinical management of cumulative trauma disorder is based upon the identification and treatment of individual component pathologies and, frequently, referral to a knowledgeable occupational therapist with an understanding of ergonomic behavioral, postural, and workspace modification. Most commonly, these individual pathologic entities are carpal tunnel syndrome, cubital tunnel syndrome, trigger finger, and De Quervain's tenosynovitis. In this article, the anatomy, diagnosis, and treatment of each of these disorders will be considered separately. In addition, since these clinical entities are often use-related, special attention should be directed toward biomechanical and ergonomic considerations.

Carpal Tunnel Syndrome

The median nerve arises from the anterior cord of the brachial plexus and emerges anteriorly below the cubital fossa at the elbow, passing from beneath the aponeurosis of the flexor digitorum superficialis and pronator teres muscles, and coursing distally into the wrist. At the level of the wrist, the median nerve enters a quadrangular fibro-osseous tunnel, known as the carpal tunnel.

The carpal tunnel is bordered on three sides by bone and on one side by a fibrous ligament. In the anatomic position, with the palms facing upwards, the carpal tunnel is bounded laterally, dorsally, and medially by the carpal bones. The "roof" consists of a thick, dense fibrous band, the transverse carpal ligament. The carpal tunnel is a hard, nonexpansile structure that houses the median nerve, along with the nine flexor tendons to the fingers and thumb. After exiting distally from the carpal tunnel, the median nerve divides into common digital nerves, which in turn bifurcate, providing sensibility to the palmar aspects of the thumb, index finger, middle finger, and typically the radial aspect of the ring finger. After entering the carpal tunnel, the median nerve also gives rise to its motor branch, which supplies most of the thenar muscles of the thumb.

Because of the low mechanical compliance of the carpal tunnel, swelling within the carpal tunnel will lead to increased hydrostatic pressure within the carpal tunnel. A variety of factors may contribute to swelling within the carpal tunnel. Tenosynovitis,[1,2] amyloid deposition,[3] fibrosis,[4,5] and hyalinosis[4,5] of the flexor tenosynovium within the carpal tunnel have all been widely speculated to be etiologic factors in the development of compression neuropathy of the median nerve.

Regardless of specific pathologic findings within the flexor tenosynovium, swelling of this tissue from longstanding edema, vascular stasis, and inflammation seems to be a final common final pathway resulting in increased carpal tunnel pressures. Small, highly repetitive movements requiring minimal amplitudes of tendon excursion may engender the development of interstitial edema and venous and lymphatic stasis. These low-energy movements are thought to be of insufficient force and excursion to allow the development of contractive forces necessary to generate venous and lymphatic drainage of the carpal tunnel and hand (R.W. Beasley; personal communication). Thus, carpal tunnel syndrome seems to be seen more commonly among users of low-force keyboards, such as computer keyboards, than among users of the higher-force keyboards of manual typewriters (R.W. Beasley, personal communication). The nature of finger motion is also subtly but significantly different between these two keyboard types. Higher-force keyboards may require the recruitment of the intrinsic muscles of the hand (interossei and lumbricals) to bring about the simultaneous interphalangeal joint extension and metacarpophalangeal joint flexion necessary to forcefully press a typewriter key. In contrast, with the low-force keyboards of computer workstations, most finger motion is generated within the extrinsic flexor muscles of the forearm, and far less intrinsically motored interphalangeal joint extension is required. Thus, the relative exclusion of intrinsic muscle use with low-force keyboards may result in significantly increased interstitial edema and vascular stasis.

Carpal tunnel pressures are a well-

studied function of wrist position. Carpal tunnel dimensions decrease with both wrist flexion and wrist extension.6 Thus, carpal tunnel pressures are elevated with either wrist flexion or wrist extension.7,8 Rojviroj and colleagues9 demonstrated carpal tunnel pressures to be the lowest with the wrist in neutral position, highest in 90 degrees of dorsiflexion, and significantly elevated with wrist palmar flexion. Thus, sustained static flexion of the wrist, as might be required to operate a dental drill, particularly working in the "clock" position about the dental chair,10 may result in an increased incidence of carpal tunnel syndrome among dental health care workers. In addition, the sustained fine but firm posturing of the hand required for dental procedures, with minimal amplitudes of intrinsic muscle excursion, may contribute to the development of edema and vascular congestion within the hand and carpal tunnel. It is well-established in the literature that musculoskeletal complaints occur with high frequency among dental personnel10,11 In one study, dental hygienists were found to be 5.2 times more likely to be told they had carpal tunnel syndrome, and 3.7 times more likely to meet accepted criteria for its diagnosis.10

When carpal tunnel pressures become sufficiently elevated, ischaemic neuropathy of the median nerve may occur, clinically manifesting as carpal tunnel syndrome. Patients with carpal tunnel syndrome have significantly elevated carpal tunnel pressures compared to patients without carpal tunnel syndrome.9 Carpal tunnel pressures in excess of 30 to 60 mmHg result in paresthesias in the median nerve distribution,12 the signature feature of carpal tunnel syndrome. Because of the orientation of the sensory fibers of the median nerve at the level of the carpal tunnel, sensory abnormalities typically affect the middle and index fingers more than the thumb. Any sensory disturbances in the distribution of the median nerve may reflect compression neuropathy within the carpal tunnel. Patients usually present with paresthesias, hyperesthesias or even dysesthesias of the radial three and one-half digits. Other patterns of sensory disturbances in carpal tunnel syndrome may relate to normal anatomic variations in median innervation or to segmental compression or ischaemia of the nerve. Hence, patients may present with numbness or paresthesias of the middle finger only, the thumb only, or, rarely, all of the fingers.

Because the motor branch of the median nerve generally originates from the main trunk of the nerve within or distal to the carpal tunnel, elevated carpal tunnel pressures may also result in weakness of the thenar muscles of the thumb supplied by the motor branch. Thus, weakness, clumsiness, an increasing tendency to drop objects, and difficulty with fine manipulation, such as required for buttoning clothes or sewing, may be the presenting motor complaints in patients with carpal tunnel syndrome.

Clinical experience suggests that carpal tunnel syndrome is accurately diagnosed by the presence of any two of three criteria:

- Symptoms strongly suggestive of carpal tunnel syndrome;
- Physical signs that strongly implicate compression of the median nerve within the carpal tunnel; and
- Electrodiagnostic studies demonstrating significant slowing of median nerve conduction velocities across the wrist.

Therefore, in the absence of either a convincing history or strongly persuasive physical findings to suggest carpal tunnel syndrome, nerve conduction studies may be necessary to confirm or exclude such a diagnosis. In patients with a classic history for carpal tunnel syndrome supported by highly suggestive physical findings, confirmatory nerve conduction studies may be unnecessary (and uncomfortable). However, even with a strongly suggestive history and a convincing physical examination, nerve conduction studies may be useful in providing objective measurements to document the severity and reversibility of nerve and thenar muscle damage.

Figure 1. The classic pattern of diminished sensibility in carpal tunnel syndrome -- "splitting" of the ring finger occurs because sensibility over the ulnar aspect of the ring finger is provided by the ulnar nerve.

The patient's history is the single most predictive factor in establishing the diagnosis of carpal tunnel syndrome. Patients complain of painful paresthesias in the median nerve distribution that are usually worse at night, but significantly improved during the course of the day. Classically, patients are awakened with painful paresthesias. The frequency of nocturnal wakening may be related to the severity of the condition.

Physical examination may be quite variable but is most supportive of a diagnosis of carpal tunnel syndrome when sensibility is subjectively and objectively diminished in the thumb, index finger, middle finger, and ring finger (**Figure 1**). "Splitting" of the ring finger, in which the radial aspect of the ring finger (supplied by the median nerve) exhibits decreased sensibility but the ulnar aspect (supplied by the ulnar nerve) exhibits normal sensibility, is particularly suggestive of carpal tunnel syndrome. Sensibility should be normal over the thenar eminence of the thumb. This area is supplied by the palmar cutaneous branch of the median nerve, which originates proximal to the carpal tunnel and is therefore unaffected by the compression. Other highly suggestive physical findings include the subjective report of "electrical"

shooting sensations to the middle finger, index finger, or thumb when the base of the palm is tapped (Tinel's sign) or when sustained deliberate pressure is applied over the carpal tunnel (Durkan's sign). Phalen's test is a quantitative test, which roughly correlates with the level of irritability of the median nerve at the carpal tunnel. The patient's wrist is passively flexed, and the number of seconds after which the patients reports the onset of paresthesias to one or all of the radial 3½ digits is recorded. Paresthesias within 60 seconds of wrist flexion are considered diagnostic of carpal tunnel syndrome. Phalen's test is positive in 66 percent to 88 percent of patients with carpal tunnel syndrome,13-15 whereas Tinel's sign has been shown to have a positive predictive value of only 56 percent to 67 percent.13,14 However, a positive Tinel's sign associated with a positive Phalen's sign has a positive predictive value of 88 percent. Durkan's sign is independently positive in 87 percent13 to 100 percent14 of patients with carpal tunnel syndrome. Therefore, a highly "positive" physical examination combined with a history of symptoms classic for carpal tunnel syndrome may accurately establish the diagnosis of carpal tunnel syndrome without the need for confirmatory nerve conduction studies. Some of the common symptoms and signs of carpal tunnel syndrome are shown in **Table 1**.

Nerve conduction studies measure the conduction velocity of the median nerve across the carpal tunnel. Electromyelography records patterns of electrical potentials (positive sharp waves and fibrillation potentials) within the abductor pollicis brevis muscle of the thumb, which may indicate the presence of muscular denervation seen in severe neuropathy. The clinical utility of electrodiagnostic testing is threefold. If the patient has either a nonclassical history or a poorly defined physical examination, the demonstration of slowing of nerve conduction or denervation on electromyelography may confirm or support an otherwise uncertain diagnosis. Even if there is little doubt of carpal tunnel syndrome on clinical grounds, electrodiagnostic studies may be useful in two ways. Associated compression neuropathies of the ulnar nerve or of the median nerve more proximally may be evaluated. In addition, the severity of carpal tunnel compression may be inferred from the presence or absence of positive sharp waves and fibrillation potentials and from the degree of slowing of conduction velocity. Fibrillations or positive sharp waves on electromyelography indicate that muscular denervation is present. Irreversible atrophy of the thenar muscles may result from the less than timely resolution of carpal tunnel syndrome in such severe cases.

Conservative treatment for mild to moderate cases of carpal tunnel syndrome includes splintage and steroid injections. A wrist splint will support the wrist in a neutral or slightly extended position so that the carpal tunnel maintains a geometry with maximum volume and minimum intraneural pressure.9 Splinting of the wrist is particularly helpful at night, when patients tend to sleep with the wrist flexed and when carpal tunnel swelling may be increased due to inactivity. Steroid injections are directed toward decreasing the volume of the carpal tunnel contents by exerting a powerful anti-inflammatory effect upon the flexor tenosynovium. Both of these conservative measures serve to minimize the volumetric discrepancy between the carpal tunnel itself and the carpal tunnel contents -- i.e. the median nerve and flexor tendons -- thus lowering intraneural hydrostatic pressures.

For patients with moderate to severe carpal tunnel syndrome or for those who fail to improve with conservative measures, surgical release of the carpal tunnel may be indicated. Division of the transverse carpal ligament, which forms the roof of the tunnel, increases the anteroposterior and transverse dimensions of the carpal tunnel, resulting in a 24 percent increase in the volume of the carpal tunnel.16 Increased intraneural blood flow is observed within 60 seconds following release of the transverse carpal ligament.17 Carpal tunnel release may be performed either through a single 2 to 4 cm long incision placed longitudinally over the palm (open carpal tunnel release) or, more recently, with the assistance of a small endoscope (endoscopic carpal tunnel release).18,19 Either procedure is generally performed as a short outpatient procedure, usually requiring only local or regional anesthesia. Patients are generally discharged 60 to 90 minutes after surgery with a small dressing splint that leaves the fingers free to move. Relief from preoperative symptoms of carpal tunnel syndrome is variable, depending on the severity and duration of the carpal tunnel syndrome. However, generally patients note significant improvement immediately following surgery. Clinical improvement then continues several months afterward, as the chronically compressed and ischemic median nerve slowly recovers within its new carpal tunnel environment.

Recurrence of carpal tunnel syndrome following adequate surgical release of the transverse carpal ligament is uncommon. Recurrent symptoms following carpal tunnel release are generally due either to incomplete surgical release of the transverse carpal ligament or to accompanying proximal compression neuropathy at the level of the proximal forearm or in brachial plexus or cervical spine.

Cubital Tunnel Syndrome

The ulnar nerve passes behind the medial epicondyle at the elbow and enters the forearm between the two heads of the flexor carpi ulnaris muscle. The cubital tunnel is a fibro-osseous space bounded laterally by the olecranon and medially by the medial epicondyle with the aponeurosis of the flexor carpi ulnaris forming a fibrous roof. Compression

Figure 2. The classic pattern of diminished sensibility in cubital tunnel syndrome -- both the volar and dorsal aspects of the ring and small fingers are innervated by the ulnar nerve. "Splitting" of the ring finger classically occurs, because sensibility over the palmar radial aspect of the ring finger is provided by the median nerve.

Figure 3. Ulnar claw hand deformity. Flexion of the interphalangeal joints (by the flexor muscles innervated by the median nerve) and extension of the metacarpophalangeal joints (by the extensor muscles supplied by the radial nerve) are unopposed or weakly opposed by the intrinsic muscles of the ring and small fingers (innervated by the ulnar nerve), which normally extend the interphalangeal joints and flex the metacarpophalangeal joints.

Figure 4. Froment's sign: Weakness of the adductor pollicis and first dorsal interosseous muscles results in weakness of lateral (key) pinch. The affected hand attempts to compensate for this weakness by recruiting the flexor pollicis longus muscle, resulting in pronounced flexion of the interphalangeal joint of the thumb.

of the ulnar nerve at the level of the elbow was first described by Panas20 in 1878. Although cubital tunnel syndrome was originally used to describe ulnar nerve compression specifically within the anatomic confines of the cubital tunnel,12 the term is currently used to describe compression neuropathy of the ulnar nerve at any of several different anatomic sites around the elbow. In addition to the fibro-osseous cubital tunnel itself, other common sites of ulnar nerve impingement include the medial intermuscular septum; the Arcade of Struthers (a consistent fascial band extending from the medial intermuscular septum to the medial head of the triceps); the medial epicondyle of the humerus; and Osborne's ligament (a thickened band of the flexor carpi ulnaris aponeurosis).

Increased interstitial pressures within the soft tissues surrounding the ulnar nerve may result in neural ischemia. Elevated interstitial pressures may be further exacerbated by elbow and wrist motion. Elbow flexion, wrist extension, and/or shoulder abduction synergistically elevate intraneural pressure.22,23 With elbow flexion, the cubital tunnel narrows in caliber by 55 percent,23,24 thus increasing cubital tunnel and intraneural pressures. In addition, with elbow flexion the ulnar nerve is subject to longitudinal traction. Wrist extension, independent of elbow flexion, also stretches the ulnar nerve and passively tightens the origin of the flexor carpi ulnaris over the ulnar nerve. Active wrist flexion may also directly compress the ulnar nerve at the origin of the contracting flexor carpi ulnaris. Together, these dynamic changes with elbow flexion and wrist extension or flexion result in decreased perfusion and oxygenation of the ulnar nerve, resulting in cubital tunnel syndrome.25

These dynamic anatomic factors are important when considering the ergonomic factors contributing to the development of cubital tunnel syndrome. Static posturing of the elbow in flexion and the wrist in extension, such as might be required with some computer workstations, may have the dual effect of narrowing the confines of the cubital tunnel while tightening the origin of the flexor carpi ulnaris against the ulnar nerve. In addition, wrist extension places the ulnar nerve in traction.23 Similar upper extremity posturing may be required in the operation of dental handpieces, surgical drills and other instrumentation. Drilling in a "clock" position around the patient, with the wrist and elbows flexed, may have the combined effects of decreasing the volume of the cubital tunnel, placing the ulnar nerve in traction at the medial epicondyle, and directly compressing the ulnar nerve against the contracting flexor carpi ulnaris. Some dentists and surgeons with cubital tunnel syndrome clearly identify the operation of handheld handpieces or drills and other power tools as exacerbating activities. Other repetitive or sustained activities, particularly those combining elbow flexion with passive wrist extension or active wrist flexion could be predicted to precipitate or exacerbate symptoms of cubital tunnel syndrome. Racket sports, cycling, weight lifting, driving, blow-drying hair, and holding a telephone are frequently identified activities, which tend to aggravate cubital tunnel syndrome.

Unlike the median nerve which supplies sensibility to the radial three and one-half digits of the hand, the ulnar nerve typically supplies sensibility to the small finger and medial half of the ring finger, as well as the remainder of the medial aspect of the hand (Figure 2). Motor contributions of the ulnar nerve include innervation of the adductor

pollicis and the first dorsal interosseous, which serve to enable pinch grip of the thumb against the radial side of the index finger, as might be required, for example, to turn a key. In addition, the ulnar nerve supplies the flexor of the small finger's distal interphalangeal joint, as well as most of the intrinsic muscles of the hand. As a result, compression neuropathy of the ulnar nerve potentially results in a variety of clinical manifestations (**Table 2**). Patients typically present with intermittent paresthesias of the ulnar two digits, exacerbated by elbow flexion. Patients frequently report nocturnal wakening. Often, such patients report a habit of sleeping with their elbows flexed or their hands behind their pillow. Not infrequently, patients present with pain or aching feeling over the medial aspect of their elbow or forearm. Motor symptoms generally occur later in the course of cubital tunnel syndrome, although subtle objective motor findings may be present on careful physical examination. Difficulties referable to intrinsic muscle weakness are the earliest motor symptoms. Patients may relate a history of difficulty with writing, turning keys, or opening jars. In severe cases of cubital tunnel syndrome, the strong median-innervated flexors of the interphalangeal joints and radial innervated extensors of the metacarpophalangeal joints are unopposed or weakly opposed by the intrinsic muscles that normally exert the opposite effect. A classic ulnar "claw" deformity may result (**Figure 3**).

The clinical evaluation of cubital tunnel syndrome is similar to that of carpal tunnel syndrome. The most consistent clinical finding is a sensibility deficit in the distribution of the ulnar nerve, particularly affecting the small finger. Splitting of the ring finger, with deficient or otherwise abnormal sensibility of its ulnar aspect but normal sensibility over its radial half, is nearly pathognomonic of an ulnar sensory neuropathy. The detection of subtle sensory deficits may be enhanced by first performing provocative tests, such as sustained acute elbow flexion. If the ulnar nerve already is marginally ischaemic or irritable at the level of the elbow, then transient longitudinal traction on the nerve engendered by acute elbow flexion will make the nerve incrementally more ischaemic. An increase in paresthesias and sensibility deficits is noted in the distal ulnar distribution. Acute elbow flexion is the provocative test for cubital tunnel syndrome equivalent to Phalen's test for carpal tunnel syndrome. A Tinel sign at the elbow, wherein the patients reports shooting electrical sensations or paresthesias in the ring and small finger upon tapping of the medial epicondyle, is nearly pathognomonic of cubital tunnel syndrome. Motor involvement is assessed quantitatively as a weakness in lateral (key) pinch, which measures the opposing forces of the adductor pollicis of the thumb and the first dorsal interosseous muscle of the index finger. Qualitatively, this weakness of lateral pinch is manifested as Froment's sign: The patient is asked to play tug-of-war with a piece of paper gripped in opposition between the lateral pinch of one hand and the lateral pinch of the other. A hand significantly affected by an ulnar motor neuropathy attempts to compensate for its inability to adduct the thumb and abduct the index finger in opposition. Abduction of the thumb and flexion at its interphalangeal joint occurs instead (**Figure 4**).

Conservative treatment for mild to moderate cases of cubital tunnel syndrome are directed at preventing flexion of the elbow and the significant biomechanical effects of such motion. A splint may be used to immobilize the elbow in extension, particularly at night. However, occasionally the splint itself becomes a source of compression or irritation of the nerve at the level of the elbow. Accordingly, simply wrapping the elbow region with a bulky towel may accomplish the same goals of immobilization and may be more comfortable to the patient. Other measures of conservative therapy are directed at avoiding or at least modifying activities, which tend to aggravate cubital tunnel syndrome. Simply moving a computer keyboard inward on the desk away from the user may accomplish the desired goal of decreasing sustained elbow flexion and wrist extension. Use of certain ergonomic keyboards may allow the maintenance of a neutral wrist position while alleviating flexor carpi ulnaris strain. Lowering the level of a keyboard may also accomplish the above goals.

The surgical management of cubital tunnel syndrome is currently an area of active debate among hand surgeons. Common to all treatment plans is an adequate exploration and release of the common sites of nerve compression, such as the arcade of Struthers, the cubital tunnel, the medial epicondyle, and the leading fascial edge of the flexor carpi ulnaris. However, in addition to thorough decompression of the nerve in situ, several authors advocate transposition of the entire nerve segment anteriorly, so that the nerve no longer passes posterior to the elbow.25-27 Theoretically, by transposing the nerve anterior to the axis of elbow flexion, the ulnar nerve is no longer placed in longitudinal traction with elbow flexion. However, nerve transposition procedures require skeletonization of the nerve for sufficient lengths to permit transposition. Theoretically, this dissection results in devascularization of a nerve that is already intermittently ischaemic.28 More recently, considerable attention has been paid to the option of medial epicondylectomy, without formal transposition of the nerve.29-31 This operation has the benefit of accomplishing release of the nerve, allowing anterior subluxation of the ulnar nerve, thus eliminating the fulcrum effect of the medial epicondyle so that elbow flexion no longer places the nerve on stretch. Finally, and arguably most importantly, medial epicondylectomy accomplishes the above without the need

Figure 5. Trigger finger. Impingement of the flexor tendons beneath a relatively stenotic portion of the flexor tendon sheath (A1 pulley) results in "locking" of the affected digit in a partially flexed position

to excessively devascularize portions of an already ischemic ulnar nerve.

Stenosing Flexor Tenosynovitis (Trigger Finger)

There are no muscles within the hand which flex the interphalangeal joints of the fingers or thumb. Rather, muscular contractions within the forearm are transmitted to the fingers of the hand by way of the flexor digitorum profundus, flexor digitorum superficialis, and flexor pollicis longus tendons to produce flexion of the fingers and thumb.

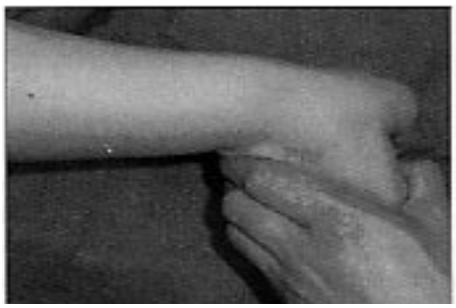
A series of transversely oriented fibrous pulleys maintains the position of the flexor tendons along the phalangeal bones, preventing the tendons from subluxing anteriorly away from the digits, which would cause "bow stringing" across the palmar aspect of the hand. For smooth painless finger flexion to occur, there must be free gliding of the flexor tendons within the fibro-osseous tendon sheaths formed by these pulleys.

Volume discrepancies between the flexor tendon sheath and the flexor tendons may lead to impingement of this free gliding mechanism by causing actual mechanical abrasion between the two gliding surfaces. As a result, progressive inflammation develops between the tendons and the sheath. "Trigger finger" is the colloquial term given to this condition, stenosing flexor tenosynovitis. A vicious cycle perpetuates and exacerbates the condition, because increased inflammation causes increased mechanical resistance to gliding (stenosis), which again produces increased inflammation. Early descriptions of stenosing flexor tenosynovitis attributed the high incidence of this entity in middle-aged women to the half-flexed position the fingers adopt for carrying shopping bags. Furthermore, because the pulleys maintain the flexor tendon in close apposition to the metacarpal head and proximal phalanx, an extremely small moment arm across the metacarpophalangeal joint results. Consequently, very large forces are must be generated within the forearm to allow finger flexion distally, and the transmission of these forces across the joints results in large sheer forces across the pulleys. Activities requiring sustained or repetitive finger flexion over a limited range of excursion engender significant sustained or recurrent sheer forces across a small segment of the flexor tendons and pulleys, resulting in flexor tenosynovitis. Such activities could include carrying heavy bags or briefcases, prolonged writing, rock climbing, or strenuously grasping certain dental instruments.

The most proximal of the palmar pulleys is the A1 pulley, located at the base of each finger overlying the metacarpal head. The A1 pulley is the site is most frequently involved in stenosing flexor tenosynovitis. Patients usually complain of a finger or thumb "catching," "clicking," or locking in a flexed position. They may require using their other hand to extend the affected digit. Patients may also complain of pain in the palm at the base of the affected finger or thumb. On physical examination, the patient generally has point tenderness over the A1 pulley at the base of the affected finger. Occasionally patients present with pain in the proximal interphalangeal or distal interphalangeal joint or in the entire finger. This is because inflammation at the A1 pulley may involve the digital nerves immediately adjacent to the flexor tendon sheath, resulting in referred pain more distally. Not uncommonly, patients complain of painful "arthritis" at the proximal interphalangeal joint; however, physical examination reveals point tenderness over the A1 pulley but no tenderness of the proximal interphalangeal joint. Similarly, patients may report numbness or paresthesias on one side of the finger due to irritation of the digital nerve more proximally.

In most cases, a tender nodule may be palpated at the level of the A1 pulley. This nodularity represents inflammation within the flexor tendon itself. The nodule moves proximally with flexion and distally with extension of the finger. When the finger is flexed, the flexor tendon nodule is proximal to the A1 pulley. As the patient attempts to extend the finger, the nodule is forced beneath the A1 pulley. At this point, extension of the finger may temporarily be prevented; the finger becomes "stuck" in a semi-flexed position (**Figure 5**). With increased force of extension, this impingement to gliding of the flexor tendon beneath the A1 pulley is overcome, resulting in a sudden acceleration in finger extension. A characteristic "snapping" of the finger results. In more severe cases of stenosing flexor tenosynovitis, it may be impossible to overcome this impingement, and the finger becomes "locked" in the flexed position. Failure to release such a "locked" trigger finger and restore a full range of extension to the finger may result in stiffness or even a permanent flexion contracture of the affected finger.

Because stenosing flexor tenosynovitis represents a volume discrepancy between the flexor tendons and the flexor tendon sheath, treatment may be directed at either decreasing the volume of the two flexor tendons or increasing the size of the tendon sheath. The former is generally attempted first by injecting the flexor tendon sheath with a small volume of a corticosteroid preparation, usually betamethasone or triamcinolone. Relief of pain with this injection is immediate and diagnostic, because it is



Figures 6a

Figures 6b

Figures 6c

Figures 6a through c. Eichhoff's test for De Quervain's tenosynovitis. The wrist is positioned in ulnar deviation, placing the abductor pollicis longus and extensor pollicis brevis tendons on stretch (Figure 6a). This maneuver alone may elicit significant pain. Inflammation within the abductor pollicis longus tendon sheath is indicated by pain on passive flexion of the thumb carpometacarpal joint (Figure 6b). Similarly, inflammation within the extensor pollicis brevis tendon sheath is suggested by pain on passive flexion of the thumb metacarpophalangeal joint (Figure 6c).

typically delivered with a small amount of local anesthetic, such as lidocaine. The lidocaine is eliminated within hours and the pain recurs. Sustained and significant relief of the stenosing flexor tenosynovitis usually begins to occur one to three weeks following the injection. Maximal therapeutic effect is not realized for at least four to six weeks following injection.

Significant clinical improvement in stenosing flexor tenosynovitis has been observed in approximately 73 percent of patients following one corticosteroid injection.32 A second injection is usually given if the first injection is not successful, and the rate of clinical improvement after a second injection is approximately 82 percent.32 Overall, steroid injections are effective in approximately 90 percent of patients with trigger finger.33 The administration of more than two steroid injections is considered by some to be ill-advised because of the cumulative local effects of the steroid on tendon strength. Spontaneous ruptures of the flexor tendons following steroid injection have been reported, although this complication is extremely rare.33 However, this potential complication should be considered when deciding between repeat injections or surgical release.

Surgery for stenosing flexor tenosynovitis increases the volume of the flexor tendon sheath at the A1 pulley. A transverse or longitudinal incision is performed over the palmar aspect of the metacarpal head, midway between the radial and ulnar neurovascular bundles. The digital nerves and arteries are protected as the A1 pulley is incised longitudinally. Upon release, the divided A1 pulley tends to splay apart, allowing the distal flexor tendon sheath to accommodate the inflamed portion of the flexor tendon without impingement during full extension of the proximal interphalangeal and distal interphalangeal joints. Inflammation within the flexor tendon spontaneously defervesces following the creation of this funnel-type geometry.

Indications for the surgical release of trigger fingers include failure of steroid injections, bilateral trigger fingers, "locked" trigger fingers, and trigger fingers in the setting of diabetes mellitus. Failure to improve after multiple steroid injections is an indication for surgical release because the poor probability of sustained improvement is outweighed by the potential risks of repeated steroid use. In general, patients with trigger fingers for more than one year ultimately require surgical release.32 Recurrent tenosynovitis in the same finger is also likely to require surgical release. Bilaterally symmetric trigger fingers are at increased risk of requiring surgical release eventually, although injection is usually attempted initially. Patients with "locked" flexion deformities due to trigger finger should be advised to consider release earlier rather than later, because steroid injection is less likely to release a locked digit and because the development of fixed flexion contractures may be a significant concern. Over half of all diabetic patients with trigger finger eventually require surgical release.34

DeQuervain's Tenosynovitis

Inflammation of the first dorsal extensor tendon compartment bears the name of the Swiss surgeon who reported five cases in 1895.35 Finkelstein, whose name is given to the classic diagnostic sign, provided a comprehensive discussion of the disorder in 1930.36

This condition is analogous to stenosing flexor tenosynovitis of the digits, but involves the extrinsic extensors of the thumb carpometacarpal and metacarpophalangeal joints. The abductor pollicis longus and the extensor pollicis brevis muscles are connected to the thumb by tendons that pass through fibrous tendon sheaths along the radial aspect of the wrist. These tendon sheaths constitute the first dorsal extensor tendon compartment of the wrist, passing over the radial styloid. Just as

in stenosing flexor tenosynovitis of the fingers, volume discrepancies due to inflammation may cause stenosis of the first dorsal compartment and result in impingement of the smooth gliding of abductor pollicis longus and extensor pollicis brevis tendons within the first dorsal compartment. The resulting inflammation between these tendons and the first dorsal compartment is known as De Quervain's tenosynovitis.

Patients typically complain of sharp pain over the radial styloid process of the wrist, the bony prominence just proximal to the wrist joint over the radial aspect of the distal forearm. Pain can be extreme, even excruciating. With severe tenosynovitis, a hard, tender nodule may be palpable within the first dorsal compartment. "Snapping" and "locking" may occur with attempts to actively extend the thumb. A diagnosis of De Quervain's tenosynovitis is seldom mistaken when there is point tenderness over the first dorsal compartment and pain with passive excursion of the abductor pollicis longus and extensor pollicis brevis tendons. This is best elicited by passively flexing the thumb carpometacarpal and metacarpophalangeal joints in succession, while maintaining the wrist in ulnar deviation (Figures 6a through c). This test can potentially localize the site of inflammation to the abductor pollicis longus or extensor pollicis brevis tendon or both. Originally described by Eichhoff, this test is frequently erroneously referred to as Finkelstein's sign.37,38 Finkelstein's sign is elicited when the patient experiences increased pain when the wrist is deviated ulnarly with the thumb clenched tightly within the fist. Eichhoff's maneuver rather than Finkelstein's is more commonly performed by hand surgeons to establish a diagnosis of De Quervain's tenosynovitis. Finkelstein's and Eichhoff's tests may be positive and tenderness may be elicited over the first dorsal compartment in other conditions, such as degenerative arthritis of the carpometacarpal joint of the thumb. Therefore, the gold standard for the diagnosis of De Quervain's tenosynovitis is the total relief of pain following the precise injection of a small quantity of local anesthetic into the first dorsal compartment.

Predisposing activities include postures that maintain the thumb in abduction and extension. In addition, ulnar deviation places traction on the tendons of the abductor pollicis longus and extensor pollicis brevis tendons. Nursing mothers and, more recently, fathers of newborn babies, seem to be at some risk for the development of De Quervain's disease. This is probably due to the need to support the head of the infant with a flexed ulnarly deviated wrist and an extended abducted thumb. De Quervain's tenosynovitis also frequently affects computer users who utilize a mouse or trackball. It appears to be less frequent among glide pad users and laptop users who navigate by means of a small rubber button located between the G, H, and B keys. The reason for this predisposition may lie in the postural requirements for mouse and trackball use in which the thumb is typically maintained abducted and extended as the hand is held in a hovering position over the mouse or trackball.

Also at some risk for developing De Quervain's tenosynovitis are dentists and surgeons, who utilize instruments such as wide-handled dental handpieces that require posturing the thumb in an extended and slightly abducted position to stabilize and activate the instrument. At the same time, patient positioning may necessitate some degree of wrist flexion and ulnar deviation by the operator.

As with tenosynovitis of the digital flexor tendon sheaths, De Quervain's tenosynovitis is initially treated with injection of a corticosteroid preparation followed by splint immobilization. Anecdotally, the experience of many physicians is that steroid injections for De Quervain's are less effective than for trigger fingers. However, when administered by a skilled hand surgeon, the efficacy of corticosteroid injection for DeQuervain's disease is approximately 71 percent following one injection and 83 percent following two injections.39 The poor reputation of steroid injections for De Quervain's disease is probably due to the failure of many treating physicians to recognize the existence of two or even several anatomically separate sheaths within the first dorsal compartment. An "extra" slip of abductor pollicis longus tendon was originally regarded as an "aberrant tendon,"40 but it is now accepted that several slips of abductor pollicis longus tendon may be quite common and that they may be separated anatomically by significant septation. Among Western populations, the existence of independent abductor pollicis longus and extensor pollicis brevis tendon sheaths occurs with a prevalence ranging between 26 percent to 34 percent.41 Among Asians, independent compartments for the abductor pollicis longus and extensor pollicis brevis tendons occur in approximately 80 percent of wrists.42 Therefore, De Quervain's tenosynovitis differs quite distinctly from stenosing flexor tenosynovitis in that the existence of a multiply septated first dorsal extensor tendon compartment is more the rule than the exception. Multiple injections may be required to adequately treat all subcompartments of the first dorsal compartments. With proper injection of all compartments, steroid injection should result in complete and lasting relief of De Quervain's disease in 80 percent of cases.39 When surgery was required following failure of multiple steroid injections, a separate extensor pollicis brevis compartment is found in 91 percent of cases, suggesting that injection may be ineffective due to the presence of the septation.39

Surgery for De Quervain's tenosynovitis, when indicated after failure of conservative treatment, consists of division of the roof of the first dorsal compartment in order to allow smooth

gliding of the abductor pollicis longus and extensor pollicis brevis tendons. It is imperative that the surgeon look for and release any separate compartments containing the extensor pollicis brevis tendon or accessory slips of the abductor pollicis longus tendon. Otherwise, incomplete release will not relieve the patient's symptoms.

Summary

Cumulative trauma disorder represents a wide array of tendonitides, neuropathies, and other conditions in association with repetitive stereotyped activities. In the upper extremity, the most common manifestations of cumulative trauma disorder are carpal tunnel syndrome, cubital tunnel syndrome, flexor tenosynovitis, De Quervain's tenosynovitis, lateral epicondylitis, and generalized tendonitis. While the pathophysiology of cumulative trauma disorder is poorly understood, clinical management is directed at the identification and treatment of individual component pathologies, such as carpal tunnel syndrome. Long-term relief, however, may be best achieved by means of careful and well-considered modifications in work environment and in upper extremity use habits.

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To request a printed copy of this article, please contact/Neil F. Jones, MD, UCLA Hand Center, 200 UCLA Medical Plaza, Suite 140, Los Angeles, CA 90095

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Ergonomic Benefits of Surgical Telescope Systems: Selection Guidelines

B.J. Chang, PhD

ABSTRACT A longstanding myth holds that chronic neck and back discomfort or pain is a necessary evil of practicing dentistry. The use of properly selected surgical telescopes and co-axial illumination headlights has been demonstrated to prevent or in some cases eliminate chronic neck and back pain. This paper will discuss the ergonomic benefits of surgical telescopes and co-axial illumination lights, the recent advances made in surgical telescope technology, and practical guidelines for selecting telescopes.

Author and Disclosure

B.J. Chang, PhD, is a fellow of the International Academy for Dental and Facial Esthetics, a designer of advanced military and clinical vision systems, and president and chief scientist of General Scientific Corp., Ann Arbor, Mich. Several of his recent patents (awarded or pending) have been applied to designs of SurgiTel's surgical telescope and illumination systems.

Many practicing dentists and surgeons experience chronic neck and back discomfort or pain. A longstanding myth holds that chronic neck and back discomfort or pain is a necessary evil associated with the practice of dentistry or surgery.

The use of appropriate surgical telescopes and co-axial illumination headlights has been demonstrated to prevent or in some cases eliminate a clinician's chronic neck and back pain.1-6, 16-18 Conversely, surgical telescopes with improper working distances and/or looking-down angles (called "declination angles") can actually cause chronic neck and upper back pain.16

Proper lighting is extremely important for achieving maximum visual acuity. The incorrect direction of light fosters poor working postures.17 In instances when the operating light is blocked by hands, heads or instruments, clinicians crane their neck and upper bodies to achieve a better view of the operating field. Co-axial illumination minimizes shadows and focuses on the operating field. Co-axial illumination, which means the light line is parallel to the sight line, provides clinicians with shadow-free images and significantly improves working posture as well as productivity because time is not wasted adjusting the direction of the overhead illumination light.2,19 Also, the use of co-axial light can reduce cross-contamination risk between patients because clinicians do not need to touch the overhead light.

This paper will discuss the ergonomic benefits of surgical telescopes and co-axial illumination lights, the recent advances made in surgical telescope technology, and practical guidelines for selecting telescopes.

Eyes and Light

The eye is a sophisticated imaging system required for all clinical work. The iris of the eye can quickly adjust to

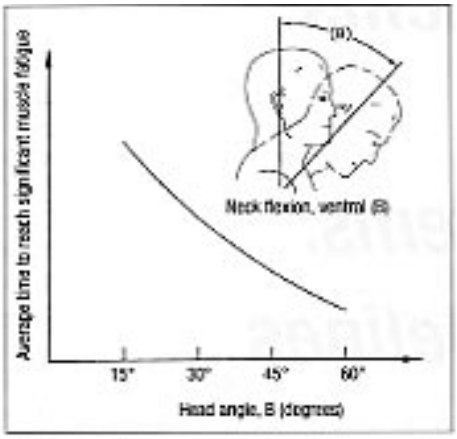


Figure 1. Relationship between head angle and neck fatigue

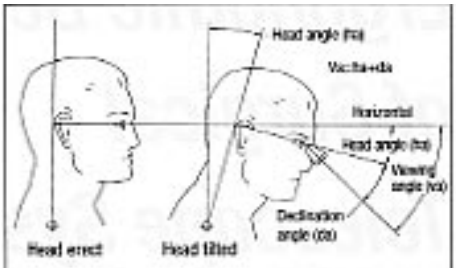


Figure 2. Head angle: viewing angle minus declination angle

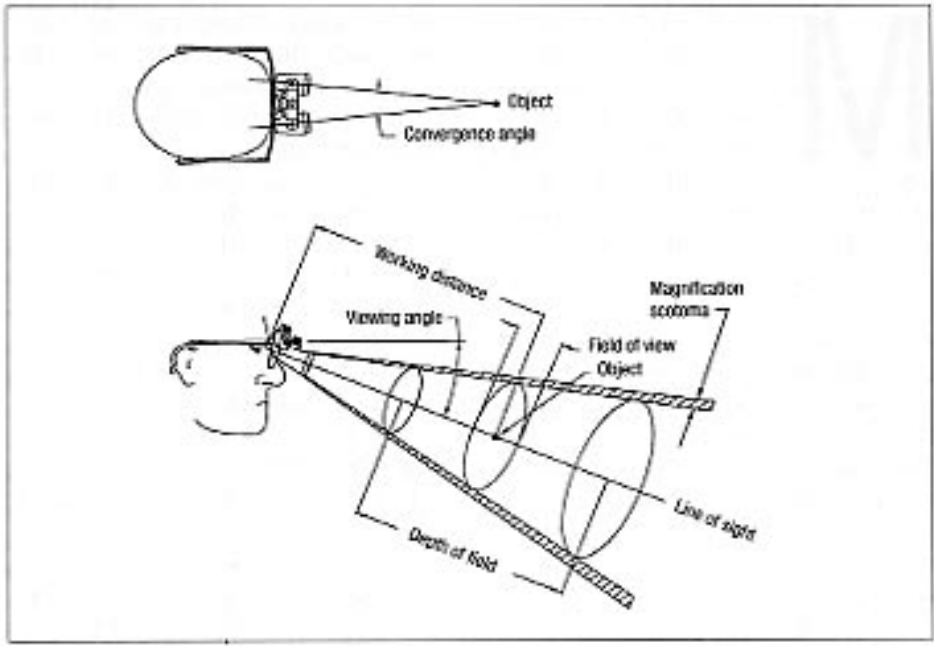


Figure 3. Terms used for surgical telescopes

incoming light to maximize the quality of images. Under bright light, the pupil diameter quickly varies from about 1 mm to 3 mm as the light level changes.7 This means the eye can easily control the amount of entering light by a factor of about 10. The increased pupil diameter increases the eye's resolution capability like a camera.7 However, the resolution capability usually diminishes at around 2 to 3 mm because the human eye is not a perfect lens. Brighter illumination can improve the depth of field because the diameter of the eye lens decreases, resulting in better resolution over a longer working range, but this may in turn reduce visual acuity.

Without magnification devices, visual acuity can be improved by moving closer to the object being examined.5,7 But moving closer alone is not good enough for many finely detailed clinical procedures. Furthermore, moving closer creates poor working postures; and over time poor postures often result in musculoskeletal problems such as chronic neck and back pain.8, 16

Head Tilt and Chronic Neck Pain

Research indicates that many dental professionals have experienced musculoskeletal discomfort in the neck, shoulder, and lower-back areas.18 Although working with neutral postures can alleviate or prevent this chronic discomfort, many dentists do not recognize the important of ergonomic benefits gained with the proper working posture.

There is a strong relationship between the working angle of the head (i.e., head tilt angle) and neck muscle fatigue or discomfort (Figure 1);8 i.e., if the head tilt angle increases, the neck muscle fatigue is more rapid. Since the declination angle of surgical telescopes will determine the degree of head tilt (Figure 2), the declination angle is the most important ergonomic factor for the design and selection of surgical telescopes. The head tilt up to 25 degrees can generally be considered a neutral head position.8 If surgical telescopes force users to tilt their heads more than about 25 degrees, they may be in an ergonomically improper posture. Inappropriate surgical telescopes foster or create poor working postures.2,9

Clinicians (both dentists and surgeons) who experienced serious chronic neck pain with the use of inappropriate surgical telescopes have been able to eliminate their chronic neck pain by improving their working postures with the use of properly fitted surgical telescopes that are designed to help them to work with neutral or erect neck postures.16

The human body is a miraculous combination of optics, electronics, chemistry, and mechanical engineering. Bones, joints, muscles, and nerves provide

CDA JOURNAL, VOL 30, Nº2

Figures 4a through e. Integration of major vision system components: (a) clip-on optical filter to be mounted inside the frame, (b) a pair of third-generation front-lens-mounted surgical telescopes, (c) clip-on co-axial light mounted onto the telescope mounting fixture, (d) optical filter cap for light, and (e) optical filter caps for telescopes.

mobility for various activities. However, working with poor postures over time will strain joints and muscles, and cause musculoskeletal problems. Aches, pain, and fatigue are important symptoms that should not be ignored.6,18

Selecting an Appropriate Pair of Surgical Telescopes

Figure 3 shows important magnification terms used in this paper. When selecting a proper pair of surgical telescopes, one must consider many factors.2,5,9 These factors can be divided into two major categories: optical-performance and ergonomic.

Also, how key system components such as co-axial headlights and optical filters are integrated with the telescopes is an important ergonomic factor.

Optical Performance Factors

Magnification power, image quality, and optical coatings are major optical performance factors. Most dental and surgical procedures can be performed with 2x to 5x power surgical telescopes.

Major brand surgical telescopes use similar quality lenses and optical coatings, and thus the image quality of individual telescopes is almost equivalent. However, the image quality of assembled telescopes can be very different depending on the accuracy of optical alignments of two telescopes. Optical misalignments reduce the image quality and often create double images in the vertical direction. Furthermore, this creates eyestrain and headaches. The convergence angle of certain telescope brands is not fixed and often easily misaligned. Once telescopes are misaligned, it is difficult for users to realign them correctly.

It is important to note that as the magnification power increases, the depth of field will decrease, making it more difficult for a person to hold images steady as he or she moves. In addition, the higher the power, the larger the magnification scotoma (the blind zone between the magnified central view and the peripheral unmagnified view).2

Ergonomic Factors

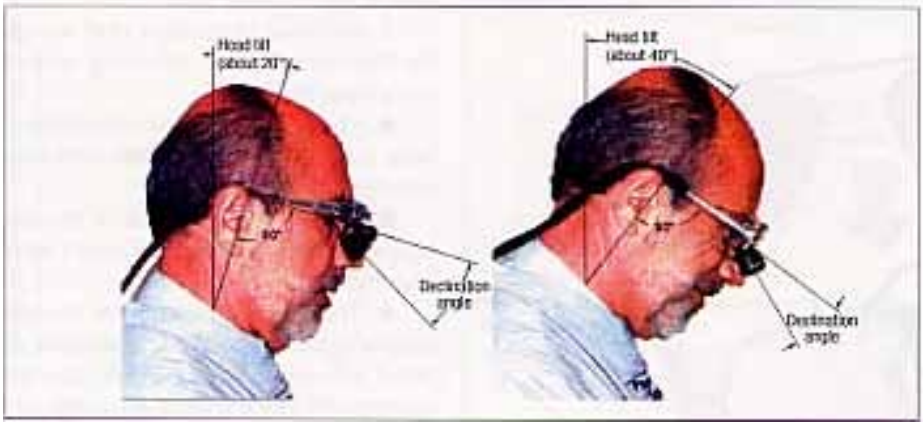
Since optical performance factors are similar among major telescope brands, ergonomic factors should be considered the major selection criteria when choosing surgical telescopes. Ergonomic factors greatly affect the quality of care, productivity, and well-being of the clinician from day to day and in the ensuing years.2,18

Ergonomic principles that should be considered when selecting surgical telescopes include:2

- They should be comfortable to wear (i.e., lightweight frames with comfortable nose pads).
- The working distance of the telescope must match with the user's working distance.
- The declination angle of the telescopes must support the clinician's desired posture, not vice versa. Also the declination angle should allow the clinician's neck and back to maintain a neutral position. It is desirable to have the declination angle adjustment option if clinicians want to achieve the maximum comfort by adjusting the working posture.
- There should enable easy integration of co-axial illumination headlights and various optical filters such as laser protection filters with telescopes. An example is shown in **Figure 4**.

Common Ergonomic Factors

Commonly discussed ergonomic factors relating to telescopes are weight, working distance, depth of field (or



Figures 5a and b. Declination angle and working postures: proper declination angle and good working posture (a) and too small declination angle and poor working posture (b).

working range), and field of view.2, 5 Clinicians can easily evaluate these ergonomic factors.

It is very important to check the weight of the telescope. The weight of newer telescopes (including frames and side shields) is less than 60g while some old designs weigh more than 100g. Heavy telescopes are uncomfortable and may impede optimum performance. Some lightweight telescopes use unstable mounting fixtures and frames that cannot maintain optical alignments.

The working distance is defined as the distance between the clinician's eyes and the work site. The working range of telescopes is determined by measuring the nearest and farthest distances within which the object remains in sharp focus or the clinician is able to achieve visual resolution (for example, 12 to 17 inches). Ideally the clinician's average working distance should be the middle point of the telescope working range.

The depth of field is the difference between the extremes of the working range. The achievable depth of field depends upon the accommodation ability of the user's eyes. Older clinicians will usually achieve shorter depth of fields. The clinician's working distance will be different for different procedures. Ideally, the working range of one pair of telescopes should be large enough to allow clinicians to use the same telescope for different procedures.

The field of view is an ergonomic factor closely related to several other factors including magnification power, working distance, peripheral vision, and magnification scotoma (blind zone between the magnified vision and peripheral vision). Having a sensible balance among these factors is very important. The size of the linear field of view will be larger as the working distance is longer and be smaller as the magnification power is higher. If telescopes are placed closer to the eyes, the field of view becomes larger, but the peripheral vision becomes smaller. Optimized designs should maintain a proper balance among field of view and peripheral vision.

Key Ergonomic Factors

Two key ergonomic factors are declination angle and the design of the frames. These ergonomic factors have not commonly been discussed because traditional surgical telescopes were designed to improve visual acuity but did not necessarily address ergonomics. Although poor working postures created with improper declination angles can create chronic neck and back pain,16,18 young clinicians do not realize the importance of ergonomic benefits gained with the proper working posture until they feel neck and/or back pain when they get older. Therefore, early education on ergonomics and proper working posture is very important to prevent work-related musculoskeletal problems and to improve work productivity.

The angle of declination should play the key ergonomic role in selecting proper surgical telescopes.9 The declination angle is defined as the angle between the line of sight made with the neutral eye position and the actual line of sight made by the declined eye chosen by the clinician. If the clinician has to tip the chin into the chest, the declination angle of the telescopes is too small. If the clinician has to severely decline the eyes or flex the neck backward, the declination angle is too large. Therefore, clinicians should learn how to specify their declination angles prior to purchasing a pair of telescopes.2 The head tilt angle of natural neck postures should be less than about 25 degrees.8

Figure 2 shows the viewing angle as a combination of head angle and declination angle. The ideal angle of declination can be found by comfortably balancing the neck and eyestrain.2,6 **Figure 5** shows declination angles and working postures. If telescopes do not provide proper declination angles for clinical procedures, the clinician will be forced to flex the neck downward to see the work site. This overflexed neck position causes neck and shoulder pain and results in musculoskeletal problems.6,8,18

Two important advances have been made in the design of frames for surgical telescopes10,11 -- multiple sets of nose pads and customized mounting positions of the nose pads for different facial types. The height of the nose from person to person varies greatly from less than 5 mm to more than 30 mm. Therefore, fixed nose pads may prove to be ergonomically incorrect for certain face types.

Co-Axial Illumination Light Systems

Adequate light must be present for human eyes to function effectively. As the amount of room light increases, the visibility of objects also increases. Therefore, it is often perceived that more light is better. However, excessive light (more than the iris of the eye can effectively handle) obscures details of objects and presents glare problems. The reduced pupil size due to the excessive light will increase the depth of field but will in turn decrease the eye's resolution capability.7 The perceived brightness of objects under the same amount of illumination will be drastically different as the background illumination level varies.12 When the background illumination is lower, the object becomes brighter because the eye can allow more light to enter the retina by opening the iris.

To achieve the best visual comfort, one should maintain an optimum target-to-background brightness ratio (T/B ratio), where the target is defined as the work site. The T/B ratio is the ratio of the target brightness to the brightness of the area immediately surrounding the work site. This ratio affects both visual acuity and comfort. Guth recommended a ratio of 3:1 for the visibility (or detectability) and visual comfort.12 In other words, the work site should be at least three times brighter than the background. However, for many clinical work sites, the background is even brighter than the work site, the exact opposite of what is recommended.

Co-axial illumination light systems come in two types: lights mounted to headbands and lights directly mounted to the surgical telescope-mounting fixture. The separate, headband-mounted light is generally heavy and cumbersome, as well as easily misaligned with the telescopes and the clinician's line of sight. In contrast, a light directly clipped onto the telescopes becomes an integral part of the telescopes and the illumination direction will always stay in line with the telescopes and the clinician's line of sight.

The co-axial illumination light is available in either fiber-optic or direct-lamp styles. The brightness of fiber-optic lights depends upon the light source. Brightness from 2,000 to 70,000 lux (or 200 to 7,000 foot-candles) can be generated with light sources available in the dental and medical markets. Intense fiber-optic lights are primarily used for major surgical procedures. The required illumination level will vary according to the background illumination level. To avoid eye fatigue, clinicians should avoid intense illumination that exceeds the adaptation capability of the eye.

Portable direct halogen lights can usually generate 2,000 to 10,000 lux (or 200 to 1,000 foot-candles) and can be operated with a portable battery pack. These direct halogen lights are adequate for minor surgical procedures, general dental procedures, and clinical examinations. Many intricate tasks, including surgical procedures, can effectively be performed at approximately 10,000 to 15,000 lux if the T/B ratio is properly maintained.13,14,15

Co-axial illumination offers several advantages -- elimination of shadow, elimination of the need to use the overhead operatory light, elimination of the need to adjust the overhead light, and cross contamination between patients. Dental professionals spend many hours per year adjusting and maintaining the overhead operatory light.

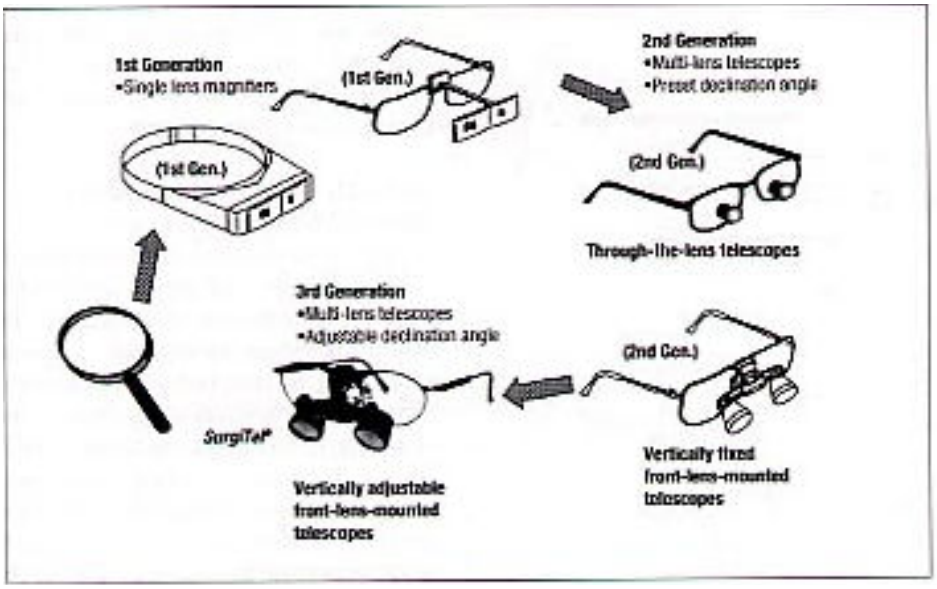


Figure 6. Evolution of magnification loupes

Types of Surgical Telescopes and Their Unique Features

Clinical magnification loupes have been evolutionary (**Figure 6**). Magnification loupes can be classified into three main categories:5

- First generation: single-lens diopter magnifiers;
- Second generation: surgical telescopes with preset declination angles; and
- Third generation: surgical telescopes with the fully adjustable declination angle option.

The second-generation surgical telescopes with preset declination angles can be divided into two types: through-the-lens surgical telescopes and vertically fixed front-lens-mounted surgical telescopes. The third-generation surgical telescope with the fully adjustable declination angle option is called the vertically adjustable front-lens-mounted

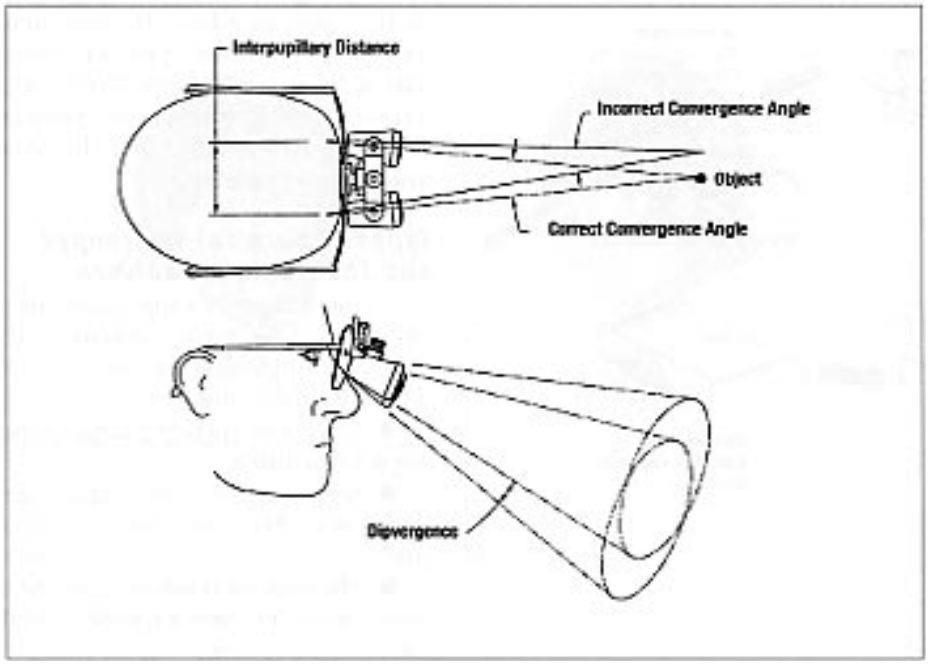


Figure 7. Misalignments of surgical telescopes: convergence and dipvergence

surgical telescope. The most noticeable and important difference among these three types is the setting of their declination angles. This paper will not discuss first-generation diopter magnifiers because they are not practical for most clinical applications.

Through-the-Lens Surgical Telescopes

Fixed-mounted, second-generation through-the-lens telescopes have been used as visual aids by low vision patients and surgeons for many years.

While through-the-lens telescopes are less bulky and more esthetically pleasing to many, it is a misconception that they can provide a full range of declination angles for all clinical procedures. The range of customizable angles with conventional through-the-lens telescopes is very limited due to the physical constraints of eyeglasses (i.e., eyeglass lens size). Although such telescopes are called custom telescopes, their declination angles cannot be customized for many clinical procedures. Therefore, through-the-lens telescopes should be referred as fixed telescopes. Their declination angles are predetermined and fixed for a specific working posture. Thus, they are not ergonomically correct for situations in which the clinician changes working position for a specific clinical procedure, such as standing for removable prosthodontics or oral surgery. In these instances, the clinician must adjust his or her neck posture (i.e., head tilt angle) to accommodate for the fixed position of telescopes. Lastly, should the user need a prescription, the through-the-lens telescope must be returned to the manufacturer for a modification at an additional fee.

Vertically Fixed Front-Lens-Mounted Surgical Telescopes

There are subtle differences among manufacturers of vertically fixed front-lens-mounted surgical telescopes. Some manufacturers do not fix the convergence angle and allow users to do so (**Figure 7**). This often creates serious telescope alignment problems. The optical alignment of two separate telescopes is not trivial and nearly impossible without the use of precision alignment instruments. The do-it-yourself adjustment of the convergence angle often creates a misalignment in the vertical direction (called "dipvergence") (**Figure 7**). If the dipvergence is large, the user can see double images in the vertical direction. If the dipvergence is small, the user's brain can correct the problem, but the user will likely experience dizziness and/or headaches. Most front-lens-mounted telescopes allow the clinician to adjust the interpupillary distance for different working distances and/or multiple users.

The achievable declination angle varies according to the clinician's nose height; i.e., the higher the nose height, the smaller the declination angle. Double hinges without the vertical adjustment capability will limit the adjustment of the declination angle of telescopes (**Figure 8**). Unlike through-the-lens telescopes, any local optician can change the eyeglass prescription with vertically fixed front-lens-mounted telescopes.

Vertically Adjustable Front-Lens-Mounted Surgical Telescopes

This style of telescope allows users to vertically adjust and set the declination angle for their desired neck postures. This surgical telescope incorporates a special mounting fixture (which has double hinges and a vertical slide) that allows clinicians to adjust the declination angle for a wide range of clinical procedures. Generally, these telescopes will allow users to achieve a more comfortable working posture as compared to both the conventional through-the-lens and the vertically fixed front-lens-mounted telescopes.3 **Figure 9** shows working postures with various type telescopes.

Vertically adjustable front-lens-mounted telescopes can easily be adjusted for different procedures, unlike the other telescopes discussed. As with the vertically fixed front-lens-mounted telescopes, any local optician can easily change the eyeglass prescription

General Guidelines for the Selection of Surgical Telescopes

Some statements about surgical telescopes are misleading, at best confusing. To avoid mistakes, one should follow general guidelines when selecting surgical telescopes:

- Working posture and declination angle -- The clinician should ignore how he or she is working now and consider how he or she wants to work. Knowing one's desired working posture and declination angle of telescopes is very important for the selection of a proper pair of telescopes.
- Magnification power -- As the magnification power increases, both field of view and depth of field become smaller. If a clinician does not have any experience with telescopes, he or she may start with either 2x or 2.5x telescopes. A tall clinician who need a long working distance of more than 16 inches could even start with 3.0x telescopes because the power of a telescope decreases as the working distance increases.
- Minimum field of view (or field size) -- The clinician should determine the minimum (or adequate) field size for procedures. A telescope that gives a larger field of view may restrict peripheral vision; i.e., placing telescopes closer to eyes can increase the field size but will reduce the peripheral vision.
- Working distance and working range (or depth of field) -- The clinician should measure the working distance. The working distance of telescopes should match the clinician's working distance. Telescopes having the same magnification power and working distance will have significantly different depth of fields depending on what design criteria were used.
- Optical alignments -- Incorrect optical alignments of two telescopes will create double images and eyestrain. If the convergence angle is not permanently fixed, the clinician should not consider the telescopes unless he or she knows precision optical alignment techniques.
- Cleaning and disinfecting -- Cleaning with alcohol is not enough. In order to use proper disinfecting solutions, telescopes should be properly sealed against water. If telescopes are not properly sealed, cleaning and disinfecting them effectively will be difficult.

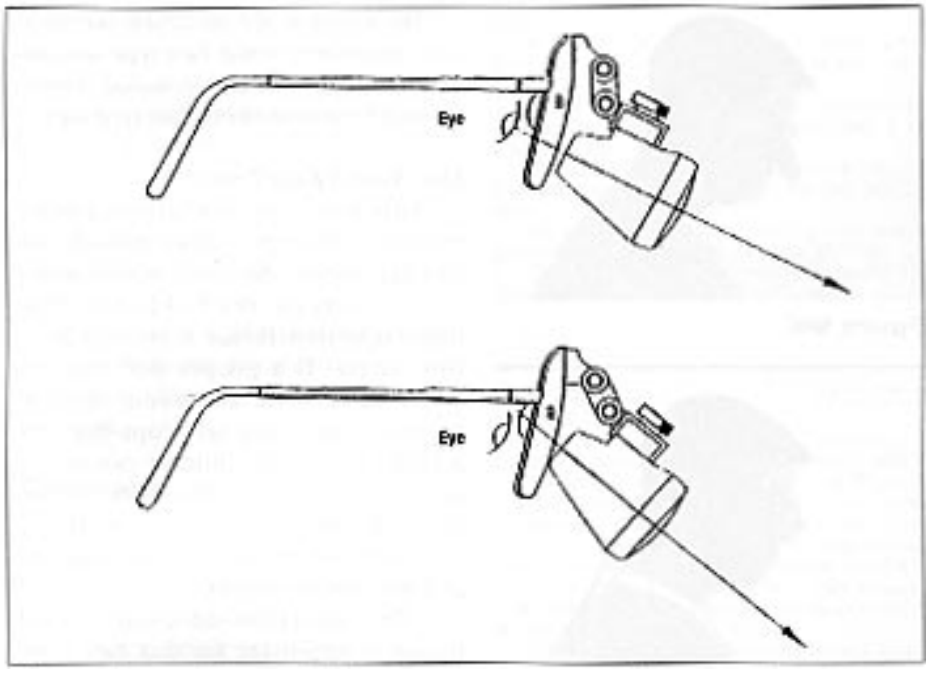


Figure 8. Double hinges and declination angle adjustment: need of the vertical adjustment

Face Types and Selection Guidelines for Each Face Type

To select a proper pair of surgical telescopes for a specific face type, various facial features should be considered, but study indicates that the height of the nose is the most important and distinctive feature to consider when selecting a proper pair of surgical telescopes.

The height of the nose is the distance between the inside corner of the eye and the top of the bridge of the nose (Figure 10). The height of the nose from person to person varies greatly from less than 5 mm to more than 30 mm. The inside corner of the eye is about 4 mm lower than the center surface of the cornea. Based on the height of the nose (i.e., low nose or high nose), all face types can be arbitrarily classified into the following four types:

1. Low nose 1 face type -- 0 mm to 10 mm high;
2. Low nose 2 face type -- 11 mm to 15 mm high;
3. High nose 1 face type -- 16 mm to 20 mm high; and
4. High nose 2 face type -- more than 20 mm high.

Traditional frames do not fit the Low nose 1 face type well. Therefore, clinicians with such a face type should pay attention to selecting frames with proper nose pads. On the other hand, the high nose 2 face type will find it very difficult to achieve comfortable declination angles with most surgical telescopes. The key ergonomic factor for such clinicians is the declination angle. Tall high nose 2 type clinicians may experience more chronic neck pain with improperly selected surgical telescopes.

Clinicians who are looking for surgical telescopes can be divided into three general groups. General selection guidelines are given for these groups.

Figures 9a

Figures 9b

Figures 9c

Figures 9d

Figures 9a through d. Working postures with various telescopes: (a) with a conventional through-the-lens telescope, (b) with an ErgoVision through-the-lens telescope, (c) with a vertically fixed telescope, and (d) with a vertically adjustable through-the-lens telescope.

"I Do Not Know My Proper Working Posture"

Clinician's who do not know their desired postures and want to find comfortable postures with telescopes should consider one of the third-generation fully adjustable telescopes. These telescopes allow different declination angles so one can easily find a declination angle that can allow maximum comfort.

"I Cannot Wear Eyeglasses Because My Nose Is Too Sensitive"

Clinician's with a nose that is too pressure-sensitive should find a headband-mounted telescope.

"I Know My Desired Working Posture"

Clinician's who their desired working postures and want to find proper telescopes can follow the steps described below for particular face types.

Low Nose 1 Face Type

Usually front-lens-mounted telescopes will be the best choice for this face type, not through-the-lens telescopes. Through-the-lens telescopes will not significantly increase the field size, but will significantly reduce peripheral vision. The clinician can select any front-lens-mounted telescope that allows him or her to work with the desired working posture and meets optical and other ergonomic requirements. Since many frames do not fit this face type well, some clinicians of this face type like the headband-mounted telescopes.

The selection of comfortable frames is very important for this face type because nose pads of most conventional frames do not fit the nose of this face type well.

Low Nose 2 Face Type

This face type can use through-the-lens telescopes. The reduce peripheral vision but will not significantly increase the field size. The main selection factor is the declination angle. If a proper declination angle cannot be achieved, then a front-lens-mounted telescope may be a better choice. A clinician can select any telescope that allows him or her to work with the selected working posture and meets optical and ergonomic requirements.

The selection of comfortable frames is important for this face type because nose pads of most conventional frames do not fit such a face well.

High Nose 1 Face Type

Through-the-lens telescopes will provide a larger field of view than front-lens-mounted telescopes mounted on conventional frames, but conventional through-the-lens telescopes have limited declination angles for most clinical procedures. Some front-lens-mounted telescopes will provide a larger field of view similar to through-the-lens. The significant advance of a front-lens-mounted is the adjustable declination angle. The clinician can choose either front-lens-mounted telescopes or through-the-lens telescopes. The declination angle will be the major ergonomic factor in the selection of the telescope for this face type.

Most frames can fit this face type well. The clinician should check all frame options. Frame styles also affect the size of both the declination angle and the field of view.

High Nose 2 Face Type

Through-the-lens telescopes will provide a much larger field of view than front-lens-mounted telescopes mounted on conventional frames, but conventional though-the-lens telescopes cannot provide proper declination for most clinical procedures. If the field size is one's major selection factor, one should choose a through-the-lens telescopes. The declination angle will be the major ergonomic factor in the

selection of the telescopes and frames.

If a reduced field size is acceptable, one can evaluate front-lens-mounted telescopes. Most frames will fit this face type well.

Conclusion

Properly fitted surgical telescopes and lighting help clinicians achieve the total quality practice; i.e., quality patient care, work productivity, and the clinician's long-term well-being. Selecting an appropriate pair of surgical telescopes means finding a set that matches the user's face type, in addition to all other performance requirements, and will contribute to the clinicians' comfort and productivity, day to day and for the long term.

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Injury Prevention for the Practice of Dentistry

Adam J. Yoser, DC; and Ronald S. Mito, DDS

ABSTRACT There is an abundance of dental professionals with work-related pain and dysfunction. Dentistry poses a huge challenge because of the ergonomics of dental work The biggest risk factors are the awkward prolonged seated postures with no back support and the limited range of motion and isometric muscle contraction created by working in a confined area, namely the mouth. The following manuscripts offers exercises that constitute a preventive program to target the typical problem areas of the dental professional — the neck, lower back and wrist/hand.

Authors

Adam J. Yoser, DC, practices chiropractic sports medicine in Brentwood, Calif. As the co-founder of Pacific SportsMedicine Alliance, he has served as medical director for the U.S. Professional Surf Tour and the American Jiu-jitsu Association. He has lectured on injury prevention at the University of California at Los Angeles School of Dentistry and various dental symposiums in Southern California.

Ronald S. Mito, DDS, FDS, RCS(Ed), is a professor and associate dean for clinical dental sciences at the University of California at Los Angeles School of Dentistry. He is also a member of the CDA Board of Trustees and a member of the ADA Council on Government Affairs.

Using a sports medicine approach, dentistry may be viewed as a profession much like a "sport." There is an abundance of dental professionals with work-related pain and dysfunction. Dentistry poses a huge challenge because of the ergonomics of dental work The biggest risk factors are the awkward prolonged seated postures with no back support and the limited range of motion and isometric muscle contraction created by working in a confined area, namely the mouth. The physiologic effects of these elements are patterns of muscle imbalance and neuromuscular inhibition causing dysfunction and/or pain. Advances in ergonomics continue to ease the physical challenges of the dental profession. Use of office ergonomics does not replace the basics of a body being physically conditioned, however. One must try to learn how to work around the various risk factors. The ultimate goal should be to prevent injuries and maintain the health of the dental team by following a tailored program of rehabilitative exercises.

Nature of the Problem

Clearly, the practice of dentistry does not result in the contact injuries of football or hockey. Instead, the root causes of pain are cumulative microtrauma and dysfunction from repetitive overuse in awkward positions.

Microtrauma involves very minor bodily insults that repair with scar tissue that is less elastic than the unscarred tissue. Repetitive microtrauma can also

CDA JOURNAL, VOL 30, Nº2

be responsible for degenerative arthritic changes in the spine. This causes the individual to gradually experience almost imperceptible decreasing function, range of motion, elasticity of tissue, and, consequently, strength. Compensatory patterns of movement and muscle use develop, and the body becomes less efficient and prone to pain.

Muscle Imbalance

Dental postures create prolonged, repeated muscle contraction, which promotes a pattern of muscle imbalance typical of dental professionals. Muscle physiology is such that humans are designed with agonist and antagonist muscles. For a person to move a limb, two deliberate neurologic messages are sent. One is for the muscle to contract. The other is for the opposite, or antagonist, muscle to relax. Without the second message, movement at a joint cannot occur. Consequently, repetitive patterns of muscle use and contraction deliberately send a message of relaxation and disuse to specific muscle groups. This is how patterns of weakness and disuse develop.1 Knowing the typical patterns of muscle use in dentistry is necessary to design preventive exercise routines.

Isometric Muscle Contraction

The human neuromuscular system is wired for movement and range of motion. Maintained positions rapidly produce fatigue and pain as the body senses the static insult. The static contraction of muscle decreases circulation thereby affecting the nutrition to tissues. Consequently, normal elimination of muscle waste products and dispersion of fluids are interrupted.2 This is viewed in Eastern medicine as tissue stagnation and unbalanced flow of energy leading to pain. The further theory is that whichever energy pathways (meridians) are involved will cause related general health problems. Proper stretching and neuromuscular control can help counterbalance an eight-hour workday of confined, repeated positions.

Risk Factors and Prevention Tips

Prolonged Awkward Postures

Forward flexed postures put extreme compression on the lumbar spine and discs. One should not sit nor stand in a prolonged position with the upper body twisted relative to the pelvis. Both feet should be supported on the floor. In addition, sitting on a thick wallet can shift the pelvis.

Figure 1. Rhomboids, deltoids. Grasp the right elbow with your left hand, twist the upper body to the left, and pull the right arm across the body. Repeat three to five times on each side.

Figure 2. Latissimus dorsi, intercostals, shoulder girdle. Reach diagonally forward with the left arm as the right hand further pulls the left arm at the wrist. Keep pulling the arm forward as you shift your body weight backward. Repeat three to five times on each side.

Figure 3. Pectoralis, biceps. Stand about 1 foot from the wall and place your right hand with an open palm against the wall. Bend the right knee as you lean forward, stretching your chest and arm. Vary the height of your hand against the wall to stretch different muscles. Repeat three to five times on each side.

Figures 4a

Figure 4b

Figures 4a and b. Midback muscles (trapezius, rhomboid, posterior deltoid), rotator cuff. Start with the arms outreached, overhead (Figure 4a) and slowly draw a semicircle backward (Figure 4b). Use midback muscle strength, not a stretch, to perform this exercise. Repeat 15 to 30 times.

Figure 5. Extensors (trapezius, paraspinals). Push down with both hands as you lift up from your sternum and slowly look behind you. Repeat three to five times.

Figures 6a

Figures 6b

Figures 6a and b. Extensors and intersegmental musculature. Support the back of your head with both hands (Figure 6a). Look straight ahead as you allow your chin to come forward. Using moderate resistance, pull your head back as you tuck your chin (Figure 6b). Note: Keep eyes focused straight ahead for this exercise. Repeat five to 10 times.

Figure 3. Pectoralis, biceps. Stand about 1 foot from the wall and place your right hand with an open palm against the wall. Bend the right knee as you lean forward, stretching your chest and arm. Vary the height of your hand against the wall to stretch different muscles. Repeat three to five times on each side.

Excess Head Tilt/Rotation

Tilting the head to one side and rotating it diminishes the size of the inter-vertebral foramen where the nerve in the neck goes down to the hands. One should avoid extreme positions and stretch the opposite way after each procedure. Maintaining a postural sense of elongation lifting from the sternum will help keep good upper body posture. Prolonged positions with the elbows held up and out transmit a lot of tension to the shoulder girdles. One should not lift the shoulders up toward the ears and should avoid extreme neck positions.

Standing vs. Sitting/Static Load

Studies indicate that sitting creates significant increased lumbar disc pressure relative to standing. When one is standing, the disc pressure is about 35 percent of the pressure in the relaxed sitting position. Forward flexion, as in typical dental postures, is a further

Figure 8. Trapezius, levator scapulae. Bring your left arm behind your back. Turn your head to the right and gently pull the head forward with your right hand. Repeat three to five times on each side

increase in disc pressure.3 The number of hours sitting requires regular breaks. Use of specific stretches allows one to break the static load and overuse patterns. One should to try to incorporate standing during dental procedures.

Patient Positioning

Correct use of pillows or magnification is sometimes needed to obtain the proper focal length. A person strains to see with his or her entire body as well as the eyes. The patient should be repositioned to attain an appropriate focal length and good postural position.

Use of Mirror/Eyesight

The body strains for correct vision. It is recommended that one refocus one's eyes on a distant point at least 20 feet away after sustained concentration. This helps maintain good vision and accommodation.

Grip/Force

Excessive force while gripping dental instruments creates overuse of hand and forearm muscles. One should do warm-up stretches of the wrist and hands and avoid extreme angles during work. A person who is suffering wrist and/or hand

Figure 9. Gluteals, spinal rotators. Start flat on your back with both arms outstretched. Cross your left knee toward the right shoulder. Use your right hand to help pull the left knee across your body. Repeat three to five times on each side.

Figure 10. Gluteals, hip rotators. Lie on your back with knees bent and feet on the ground. Cross the left ankle over the right knee. Use both hands to pull the right thigh toward your chest. Repeat two to three times on each side.

Figures 11a

Figures 11b

Figures 11a and b. Trunk musculature, intersegmentals. Lie on your back with knees bent and feet on the ground, about hip distance apart (Figure 11a). Gently push your tailbone into the ground as you wiggle your hips, as if you are scratching your back (Figure 11b). Progressively move the scratching from the lower back up toward your neck. Allow enough time at each vertebral level to warm up your back muscles and create spinal movement.

Figures 12a

Figures 12b

Figures 12a and b. Spinal extensors, flexors. Kneel on all fours. Allow your head to look up and your back to arch (Figure 12a). Move into the opposite movement as you round your back, tilt your pelvis and try to look into your belly button (Figure 12b). Alternate from 12a to 12b five to 10 times.

Figure 13. Iliopsoas, hip adductors. Kneel on the left knee. Look upward as you stretch your body to the right, stretching your left groin. Repeat three to five times on each side.

Figure 14. Spinal extensors. Lie on your stomach with hands placed down at shoulder level. Keep hips to the ground as you extend the upper body upward. Use your back muscles; do not push up forcefully with arms. Repeat three to five times.

Figure 15. Extensors, trunk stabilizers. Start by kneeling on all fours. Simultaneously lift the right arm and the left leg parallel to the ground. Maintain your spine in an elongated straight line. Return slowly to starting position. Repeat 10 to 30 times on each side.

symptoms may be sleeping with his or her hands curled in extreme angles. Use of a wrist brace while sleeping may be recommended.

General Principles for the Preventive Exercise Routines

While there are training aides and specialized equipment, the intent of this article is to provide a simplistic approach to prevention. Stomach crunches and sit-ups are essential exercises but are too basic to be illustrated here.

The following exercises constitute a preventive program to target the typical problem areas of the dental professional -- the neck, lower back and wrist/hand. The exercises should be performed to the point of discomfort, but not to the point of pain. A person who is already sore should take a hot shower or apply a medicated balm that "warms up" the muscles before starting the program. Some of these exercises are meant to activate supportive muscles, while others are more of a

muscular stretch. Therefore, a stretching sensation will not be felt with each exercise. The exercise routines are in a helpful numbered sequence but the order can be varied if desired.4 For the exercises to be most effective, one should:

- Try to do the routine twice a day;
- Hold each stretch for a few breaths; and
- Alternate left and right sides between repetitions.

The Exercise Routines

Neck/Upper Body

Figures 1 through 8.

Lower Body

Figures 9 through 16.

Wrist/Hand

Figures 17 through 18.

Summary

Dentistry can inherently be physically stressful. To offset this tendency, the dentist should correct his or her posture and work with the ergonomics of how the dental team functions together. The crucial preventive step is to athletically prepare one's body. After all, the real toll of neck and back pain goes beyond productivity and the longevity of a career. One's physical well-being affects the general efficiency and pleasure of practicing dentistry as well as the quality of life outside the office.

Finally, from the Earl of Darby (1799-1869) comes this last bit of inspiration: "Those who do not find time for exercise, sooner or later will have to find time for illness."

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To request a printed copy of this article, please contact/Adam J. Yoser, DC, 13050 San Vicente Blvd., #206, Los Angeles, CA 90049 or at DrYoser@aol.com.

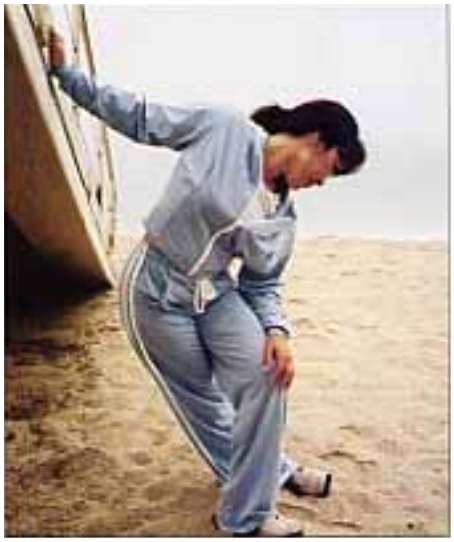

Figure 16. Gluteals, quadratus lumborum. Place your right hand on the wall and place the right foot on edge behind the left foot. Push your right hip toward the wall as you bring your head away from the wall. Note: Vary the placement of the back foot to your comfort level. Repeat three to five times on each side.

Figure 17. Deep soft tissues of the wrist. Keeping your left arm straight, grasp your left wrist firmly. Traction your wrist as you pull outward with your right hand. Repeat three to five times on each side.

Figures 12a

Figures 12a

Figures 18a and b. Forearm flexors, deep soft tissues of the wrist. Place both hand on the wall with fingers pointing upward. Lean your body weight forward to create a stretch at the forearms and wrist (Figure 18a). Vary the height of the placement of your hands on the wall to change the stretch. Try this exercise with the fingers pointing downward (Figure 18b). Repeat three to five times.

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Meeting of the Minds

Robert E. Horseman, DDS

In the early days, practice management was such an obscure subject that dental schools summarily dismissed it with the advice: "Don't spill silver nitrate on yourself or the patient, and be sure to turn everything off before departing at night."

After World War II, however, it became obvious that dentistry was no longer a "drill, fill and bill" cottage industry, but rather a candidate for the Fortune 500 list. We learned this because a new breed of dental entrepreneur in the personae of Brahe, Levoy, Barkley et al. emerged to fill the void left in our dental education. A relentlessly ebullient couple made their debut in what became known as "The Rhode Show" featuring riveting information on everything from interpersonal relationships to the intricacies of dental thank-you notes.

Out of all this came one of the greatest disasters ever visited upon the dental profession -- the concept of the staff meeting. Originally promoted by practice management gurus who had exhausted their bag of useful suggestions, it was purported to be a method of forming a happy, cohesive group whose team efforts would raise the level of production and self-fulfillment to unprecedented heights.

As envisioned by various dry-fingered business promoters, the staff meeting should be held in the morning on company time so that the paid help would suffer no loss of benefits that would otherwise render them restive and surly. The dentist, as the titular head of the practice, encourages round table participation by the staff, who, the theory goes, would offer constructive criticism and propose innovative ideas to enhance the daily grind of earning a crust. The doctor, in turn, would offer his or her ideas of increased performance in lieu of pay raises, submit whining requests for staff to be in place no later than 15 minutes after the first patient of the day is seated, and propose a special five-minute break every other month for personal phone calls.

In theory, the staff meeting idea should have worked. With all the little differences ironed out, personnel should have been purring like a basketful of cobras in no time at all. Except for one fact: The average dentist would no more willingly chair a second staff meeting after his initial convocation than undergo amputation of his personal parts without anesthesia. The staff, likewise, would sooner submit to bamboo slivers driven under their fingernails than attend a meeting where the only expected benefit is to decide when the next meeting will take place.

In our office, this potential for dissension has been solved by what

has become known as the "Unilateral Compromise Device." Based on the fact that dentists are easier to replace than good staff and fortified by our 58 years of experience as a dentist and 54 years as a husband, we have incorporated the art of complete capitulation. In other words, just let the staff run the office, a practice they instinctively follow anyway. This functions as well at work as it does at home and avoids unpleasantness in both places.

It's not that we don't have staff meetings; we do, but they are informal and take place throughout the working day.

Staff: We need Kleenex, paper towels, more turn-around time and an assistant's stool with a cup holder for coffee.

Me: OK.

Staff: We'll be late on Thursday. We have to have our nails done.

Me: No problem.

Staff: We don't like the computer, so we're going back to pegboard. Also we'll be shutting down between Christmas and New Year's.

Me: Whatever.

Staff: It's 4:30. Don't even think about starting a crown prep now!

Me: Okey dokey.

For dentists weary of trying to manage what is essentially an unmanageable profession and tired of feeling guilty for lacking the qualities of leadership advocated by practice seminar gurus, take heart. Following the precepts of Unilateral Compromise, you, too, can simply show up in the mornings, do your job to best of your ability and go home.

George Bernard Shaw, a nondentist but eccentric enough to qualify otherwise, pointed out: "Except during the nine months before he draws his first breath, no man manages his affairs as well as a tree does." He later died, offering no explanation.