

Connecting Art and Science

How Far Have We Come?

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This special issue of the *Journal of Hand Therapy* is dedicated to a review of advances in the treatment of injured tendon and nerve. The theme of this issue is to connect the most basic science with the art of practice. A shortcoming in our profession is that there is a tendency of many therapists to want "the recipe," the "how to," "the outline." Experienced therapists understand the art of therapy...the intuitive touch that can respond to inflamed tissues, sympathetic response, or suboptimal surgical technique; the personality that can teach, cajole, set patients at ease, and make them want to be compliant. But it is the responsible therapist who studies basic science and moves beyond the art of practice to understand the physiological response of the treatments they impose. This issue is devoted to *making a connection between advances in the science of tendon and nerve healing at the most basic levels with the art of clinical practice*. Some would ask: Why do therapists need to keep up with and understand experimental research and science at its most basic level? Well, why not? Should we expect those who are responsible for managing postoperative repairs for tendon and nerve to

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know less of their science than those who repair them?

The Editorial Board of the *Journal of Hand Therapy* timed this publication, in part, to coincide with the 2004 Philadelphia Hand Rehabilitation Meeting,* which was dedicated to *A Fourth Decade of Tendon and Nerve Surgery*. In doing so, we become a part of a historical tradition of critical review established by the great surgeons in our field, and we examine our own progress in hand therapy defined in the first special issue on tendon in 1989¹ and nerve in 1993².

HISTORICAL PERSPECTIVE

Forty years ago (March 11–13, 1964), an International Hand Symposium that focused on tendon surgery in the hand was organized by Drs. L. Ramsey Straub, Herbert Conway, and James Smith and held at the Rockefeller Center in New York. Keynote speakers were Dr. Joseph H. Boyes and Mr. R. Guy Pulvertaft, who reviewed current practice and defined the same problems that we face in the management of healing tendon today.³ It was decided at that

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meeting that a future ten year assessment would have merit.

The First Decade

Thirty years ago (March 16–17, 1974) James M. Hunter, MD, Lawrence H. Schneider, MD, and Evelyn J. Mackin, PT, introduced a tendon symposium entitled "The Hand: A Decade of Tendon Surgery," which was sponsored by the Committee on Musculoskeletal Disease of the American Academy of Orthopaedic Surgeons in Philadelphia. The papers from this meeting were published⁴ and introduced in the preface by Drs. Hunter and Schneider.³ The Preface and the Appendix, which was a reprint of the classic paper written by Dr. Sterling Bunnell in 1922,⁵ should humble those of us who study and research soft-tissue repair and postoperative management because the observations that they made, the questions that they asked, and the problems that they faced regarding management of the healing tendon remain the same, albeit with upgrades in knowledge and technique.

The papers published in 1975⁴ offer great perspective, and like the men from *The Greatest Generation*,⁶ the authors published in this text may never be equaled for their vision, or for the principles of treatment that they defined. The giants in hand surgery were represented in this text; the pioneers in hand therapy as well.

Bunnell's reprint of 1922 discusses the importance of atraumatic surgical technique, the problem of friction and resistance to tendon gliding, and the need for stronger suture technique.⁵ He stated that "the stronger the suturing, the more forceful and continuous can be the all-important, post-operative exercise."⁵ The papers from 1975 build on his early work and include many of the classic articles on tendon healing,⁷ vascularization,⁸ tendon suture,⁹ internal tendon forces,⁹ the digital pulley system,^{10,11} early motion programs,^{12,13} tendon grafting,¹⁴ tenolysis,¹⁵ tendon transfers,¹⁶ the intrinsic minus hand,¹⁷ and staged flexor tendon reconstruction and the active tendon prosthesis.^{18,19} Mackin's article entitled "Physical Therapy and the Staged Tendon Graft" described splinting, scar management, techniques for joint mobilization and tendon gliding—with no references, as there were none.²⁰ Josephine Cohen, OTR, wrote an article entitled "Occupational Therapy following Hand Tendon Surgery," which described evaluation, splinting, sensibility retraining, and purposeful activity.²¹ She had three references, none of which was written by a therapist. The concept of the "hand therapist" and studies to build on were nonexistent at that time.

The Second Decade

Twenty years ago, Hunter, Schneider, and Mackin again assembled the world's greatest minds in hand surgery, and continued the tradition of the "ten year review." From this Philadelphia meeting in 1984 came another classic text, *Tendon Surgery in the Hand*,²² which recorded the progress on all aspects of tendon surgery and rehabilitation to that time.

The Third Decade

Ten years ago (March 12–15, 1994), the Philadelphia group added surgery and rehabilitation for the peripheral nerve injury to the tendon symposium and again recorded progress in a text of the meeting contributions.²³ The first chapter by Goran Lundborg entitled "The Hand And The Brain" eloquently describes the hand as a sense organ and its

function for both body and soul, and brings the amazing concept of brain plasticity to the attention of hand therapists.²⁴ Nerve anatomy, repair, gliding, compression, and management were beautifully reviewed as to the state of the art for nerve at that time, adding depth to a current tendon research update.

The Fourth Decade

Last year the fourth update on tendon, the second on nerve was presented as two concomitant, but interconnected meetings, for surgeons and therapists by this same Philadelphia group (March 20-23, 2004). Many of the speakers from that meeting have written for this special addition: Amadio, Boyer, Duff, Evans, Gelberman, Koman, Kozin, MacDermid, MacKinnon, Mass, Michlovitz, Newport, Novak, Pettengill, Skirven, Steelman, Strickland, Taras, and Walsh.²⁵

And from the *Journal Of Hand Therapy*

It has been 16 years since the first special edition of the *Journal of Hand Therapy* was published,²⁶ an idea conceived in the journal's infancy by the first editor Evelyn Mackin. That first special edition was dedicated to management of the healing tendon, and focused on early passive motion programs and the basic science and clinical work that provided support for these techniques. In the editorial,¹ therapists were challenged to expand their independent study to apply existing research on biochemical and biomechanical principles to clinical practice. They were asked to consider existing questions: Do we apply what we know with precision? Do we understand the transmission of tendon force, the timing of controlled stress, the excursion and load that is needed to provide adhesion controlling tendon glide without gap formation? Can we depend on experimental studies to provide relevant information about the work of flexion, true tendon excursion in a repaired tendon subjected to various methods of exercise and joint angles, and tensile strength for the human hand? Can we explain what we ob-

serve clinically and in doing so alter our current management techniques? Do we know what we think we know? The point was made that the experienced therapist, if asked about protocols, would answer that "with almost every patient there is some alteration in splint position, exercise technique, and time-tables based on the variables of injury, surgery, surgeon's skill, tissue reaction, and the patient's behavioral patterns." And the question was asked of clinical practice: "Is this art or science?"¹

It has been 12 years since the special edition on nerve was published by the *Journal of Hand Therapy*.²⁷ In that issue, the guest editor Janet Waylett-Rendall presented "evolving concepts and techniques that reflected current treatment as well as academic and clinical research of nerves and their function"² Her vision of the global view of nerve, the impact of peripheral nerve injury on the sensory-motor cortex, and her call for better assessment and the grading of outcomes presented in that issue has influenced other researchers, and some of her themes are continued in this current issue on tendon and nerve with regard to evaluation,^{28,29} the impact of peripheral nerve injury on sensorimotor control,³⁰ and measurement of health outcomes following tendon and nerve repair.³¹

So here we are in 2005, with more pieces to the puzzle in place, but with the same questions incompletely answered, more sophisticated questions asked, and the same problem of how to reestablish glide and function in the presence of collagen deposition or adhesion formation. A brief visit to the National Library of Medicine (<http://www.ncbi.nlm.gov/entrez/query.fcgi>) yields 1,644 articles on tendon, 667 from 1995 to present; and 8,127 articles on peripheral nerve, 2,501 from 1995 to present. Clearly the scope of this issue is not complete, but we hope that a review of the past adds perspective, and reminds us that the evolution of learning is a never ending continuum. We hope that the update in this issue offers a few pearls for the experienced, sparks interest in young clinicians and researchers, and makes us all think on a grander scale as we connect the science of healing to the art of managing injured tissues.

IN THIS ISSUE

The authors of this issue are distinctive by their contributions to the literature, their innovative ideas, their dedication to the profession, and their willingness to offer our journal many hours that none of them had. They have, without exception, come through for us despite busy work and teaching schedules, and those things that we all deal with called *life*—natural disasters, family crises, illness, and maybe even a little malaise. As the invited editors, we have been relentless in our revisions, demanding of their attention to timely submission, and have taken some editorial license with publishing some personal comments (which serve to remind us of the value of mentoring) as with Paul Dell and Sforzo's³² tribute to Richard Smith, Wyndell Merritt's commentary on the Howell/Robinson paper,³³ and a fireside chat with Erik Rosenthal (who we refuse to let retire) and Carol Stoddard, which promises to be like mother's milk for the fatigued reader at the end of the journal.³⁴

Cover Art

Contemporary research for tendon and nerve healing is focused on the bioengineering of the healing of these tissues with growth factors and gene therapy as well as advances in suture materials and repair technique for both tendon and nerve. Bioengineering techniques that strengthen the repair site together with better engineered tendon repair techniques may increase tolerance for controlled active motion techniques imposed by the therapist, and decrease postoperative morbidity following tendon injury. The application of growth factors and gene therapy to our discipline does not at present have clinical application, but holds promise for the future. Mehta and Mass³⁵ note that interest in growth factors was increased 30 years ago when they were studied in relation to carcinogenesis, fetal development, and tissue healing. The words of Mr. Puvertaft ring true in his observation that "discovery in a different branch of science may lead to unexpected progress in our own discipline."³⁶

The cover was designed to make a visual connection of healing at the most basic biologic level (cellular manipulation with growth factors and gene therapy) and function at the highest level (an elite musician whose skill requires exquisite motion, dexterity, and sensibility). The schematic depicts a continuum of viral delivery of growth factors enhancing tenocyte healing, to collagen bundles in tendon, to the functioning hands of a violinist demonstrating the extreme ends in the continuum of wound healing.

The manipulation of tendon healing with growth factors is simplified and summarized by Mehta† who provided the initial schematic of this bioengineering process for the cover art: *The adenovirus carrying the DNA for the growth factor is delivered via local injection to the area of the tendon. The adenovirus attaches to the tenocyte and its DNA is brought into the tenocyte. The tenocyte then begins to take over production of the growth factor using the DNA which was provided by the virus. The growth factor is then expressed and secreted in the local environment for a number of weeks. These growth factors then act on receptors on the tenocytes in ways which are not completely understood. This causes changes in the cellular transcription of the tenocyte and hopefully promotes tendon healing (Figures 1–3).*

Our initial idea for the cover was to have a collage of the continuum of basic cellular function facilitated by the introduction of growth factors to a surgical repair to therapeutic management to a functional result. It became too busy, and we all agreed that at the risk of minimizing what we do as surgeons and therapists that in the end probably the most significant variables are biology and patient compliance, the two variables

†Vishal Mehta, MD. Personal communication, August 2004.

‡Artistry and design for the cover art were provided by Kip Carter, the Chief of Medical Illustration Services at the University of Georgia College of Veterinary Medicine. He is a certified medical illustrator specializing in human plastic and reconstructive surgery as well as veterinary medicine for domestic and exotic animals, and President-Elect for the national Association of Medical Illustrators. We thank him for his patience and expertise in the development of this beautiful cover.

that we try so hard to control, but have the least control over. The medical illustrator, Kip Carter, MS CMI,‡ who took our ideas and made them wonderful, made this point and observed that it is the connection between biology and patient that is key. We left the recognition to surgery and therapy to the articles herein.

Updates from the Experts

The lead article by Boyer and colleagues³⁷ from Washington University reviews the scientific and clinical basis for the application of force and the application of tendon excursion, addressing the questions: how much, and how far? The authors conclude based on experimental studies that 1.7 mm of excursion is sufficient to inhibit adhesion and allow functional recovery in the animal model, and that low loads of force (<5 N) are sufficient to stimulate healing without stressing the repair site. Even though their research demonstrates that 1.7 mm of excursion is sufficient to minimize gliding problems from adhesion, they recommend a postoperative program of more generous intrasynovial repair site excursion by utilizing the synergistic splint design first studied by Mayo Clinic³⁸ and advocated by Strickland.³⁹ The authors use an eight-strand core suture and allow "place and hold" with composite flexion. They agree in response to our questions that this allows great subjectivity on the patient and therapist's part for the application of force, but evidently it is workable, probably because of the caliber of surgery at their institution used in the study and the increased repair strength with an eight-strand repair. They state that they do not have a problem with the bulk of an eight-strand repair gliding through the pulley system. Their bibliography is a testament to the elegant contributions that Gelberman and his group have made to our knowledge of the biochemical and biomechanical aspects of tendon healing. Mehta and Mass³⁵ provide us with a look into the future by providing a summary of tissue engineering as it relates to tendon healing. Their article provides a brief summary of the evolution of the study of growth factors, contemporary research stud-

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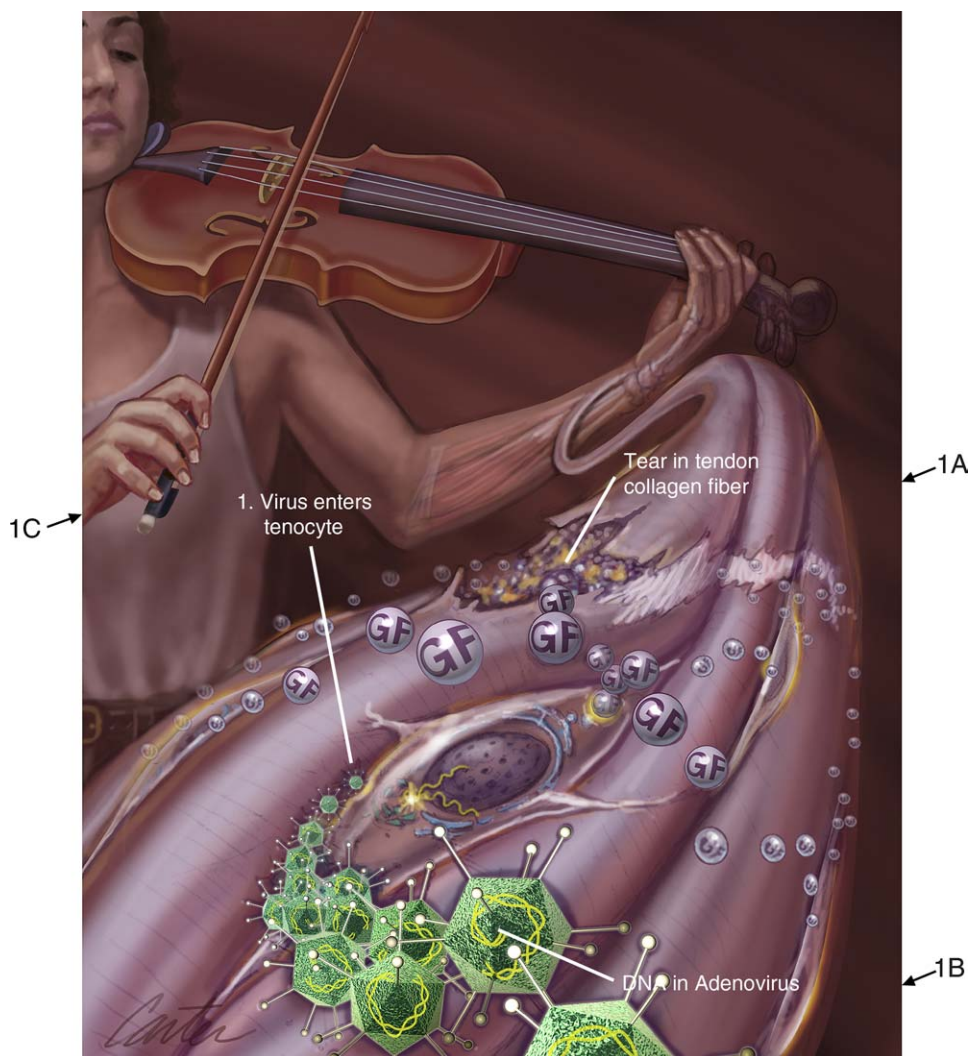


FIGURE 1. (A) Tear in tendon collage fiber. (B) DNA in adenovirus. (C) Virus enters tenocyte.

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ies, delivery methods, and the potential for the manipulation of tendon healing both to improve tensile strength and to depress excess scar formation. The link between growth factors, fibroblast proliferation, collagen deposition, and tensile strength of healing tendon has been made. It has been demonstrated that tendon cells require platelet derived growth factor and insulin-like growth factor-I in addition to mechanical load to stimulate DNA synthesis. Here is a "case in point": the interested therapist reading their article should "connect" to the reference cited⁴⁰ in which Banes et al hypothesized "that tendon cells can detect mechanical load signals, but do not interpret such signals as mitogenic unless an active growth factor is present." The comment on *mechanical load* invites us, as hand therapists, to the dance.

Strickland⁴¹ reviews flexor tendon morphology, anatomy, nutrition, tendon biomechanics, tendon healing, and problems associated with adhesion formation. He discusses repair techniques, the importance of flexor sheath preservation and restoration, and the rationale for early motion programs. He offers a succinct review of the most significant studies from the past 40 years of tendon research and provides us with an impressive bibliography. It would be fair to say that his clinical work and teachings have influenced the management of flexor tendon injuries for most hand therapists worldwide. We appreciate his willingness to add his perspective to this special issue.

Amadio⁴² discusses the biochemical aspects of tendon lubrication and the biomechanical aspects of frictional force between a tendon and

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its sheath. His article has great clinical implication for the therapist as it reviews the factors that determine a "safe zone" for the application of stress to a repair site, and emphasizes the need for therapists to be able to think in numbers regarding tensile strength and internal tendon forces applied with their rehabilitation programs. He presents us with a modification of a synergistic protocol in which wrist flexion and finger extension is alternated with wrist and metacarpophalangeal (MP) joint extension and finger interphalangeal flexion. He reviews the scientific basis for the development of this new program, which he feels delivers more effective proximal tension to the repair site while providing a "safe zone" for controlled loading. His work focuses on the importance of MP joint motion with early motion

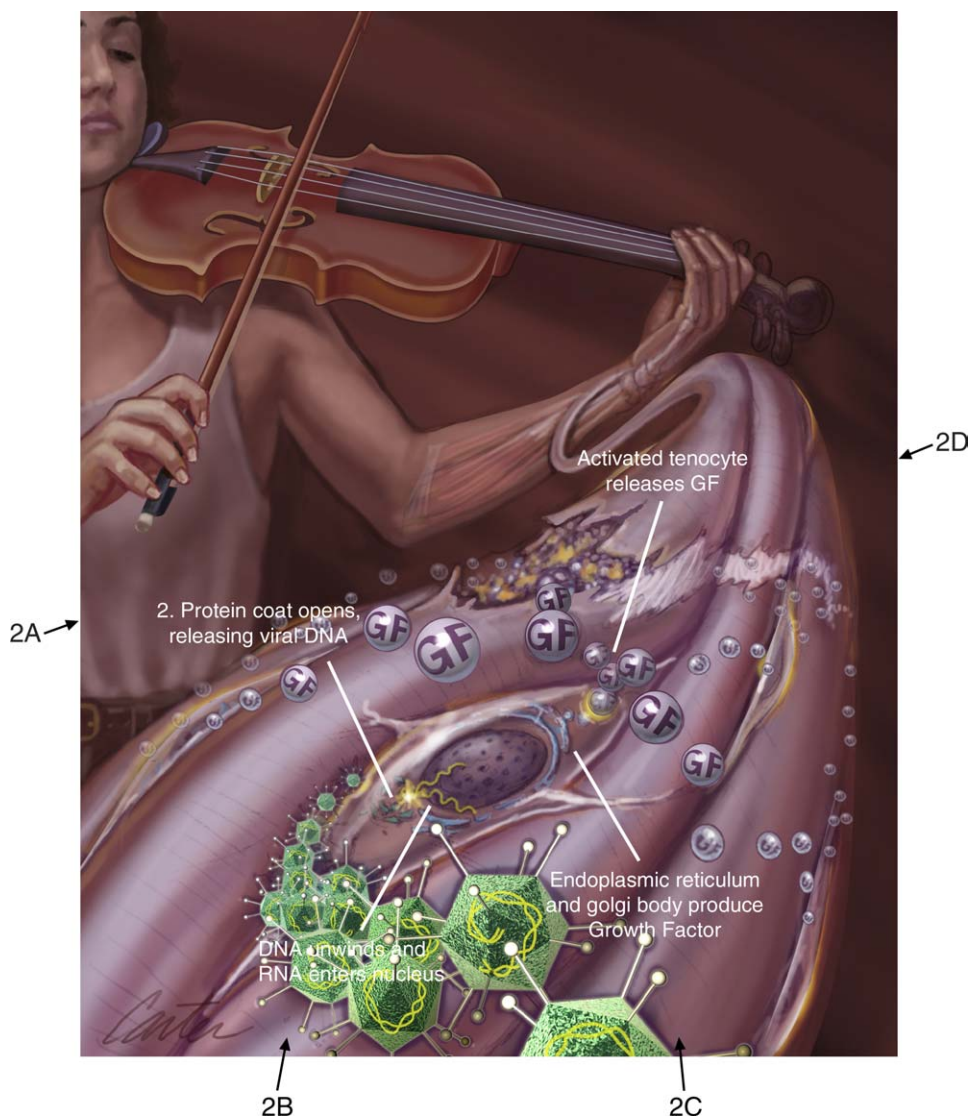


FIGURE 2. (A) Protein coat opens, releasing viral DNA. (B) DNA unwinds and RNA enters nucleus. (C) Endoplasmic reticulum and Golgi body produce growth factor. (D) Activated tenocyte releases growth factor.

382 programs. He cites the work out of St.
 383 Louis³⁷ on the importance of motion
 384 rather than loading to support his
 385 technique. He cautions the therapist
 386 that with weak repairs (two-strand
 387 core) that there may be no “safe
 388 zone” that will allow “light active
 389 motion”. He also adds another practical
 390 pearl that by waiting three to five
 391 days before initiating motion that the
 392 “safe zone” is widened, because the
 393 work of flexion (or resistance to
 394 tendon gliding) is reduced by a decrease
 395 in early inflammatory edema, and makes
 396 the point that motion that the first few
 397 days may indeed provoke fresh bleeding
 398 and thus be contraindicated.

399 Dennerline’s article helps to define
 “in vivo” tendon force mea-

surements to guide rehabilitation
 methods after surgical repair of
 flexor tendons, and also has implication
 for cumulative injury to tendon.⁴³ His
 article focuses on predicting internal
 loads associated with activity. His work
 has clinical application in that it defines
 specific internal tendon forces with
 certain activity, and reminds us that
 wrist position is critical to internal
 tendon forces, and that internal tendon
 forces at a repair site are greater than
 the external force at the fingertip. His
 new research demonstrates that during
 dynamic activity tendon forces often
 remain elevated during the relaxation
 phase.

Evans⁴⁴ article on zone I is an
 update from the original study pub-

400 lished in 1990.⁴⁵ The article was
 401 published before the *Journal of Hand*
 402 *Therapy* was accepted to the *Index*
 403 *Medicus*, and thus the information
 404 was essentially lost to future re-
 405 searchers. The article is updated to
 406 include now active motion techni-
 407 ques within a limited range of excu-
 408 sion with biomechanical review of
 409 rationale which presents the concept
 410 that the zone I flexor tendon deserves
 411 to be treated differently than the zone
 412 II flexor tendon with regard to re-
 413 habilitation technique.

413 Elliot and Southgate⁴⁶ review re-
 414 cent advances in the rehabilitation of
 415 injuries of the long flexor and exten-
 416 sor tendons of the thumb. They in-
 417 clude their clinical results with
 different suture and mobilization

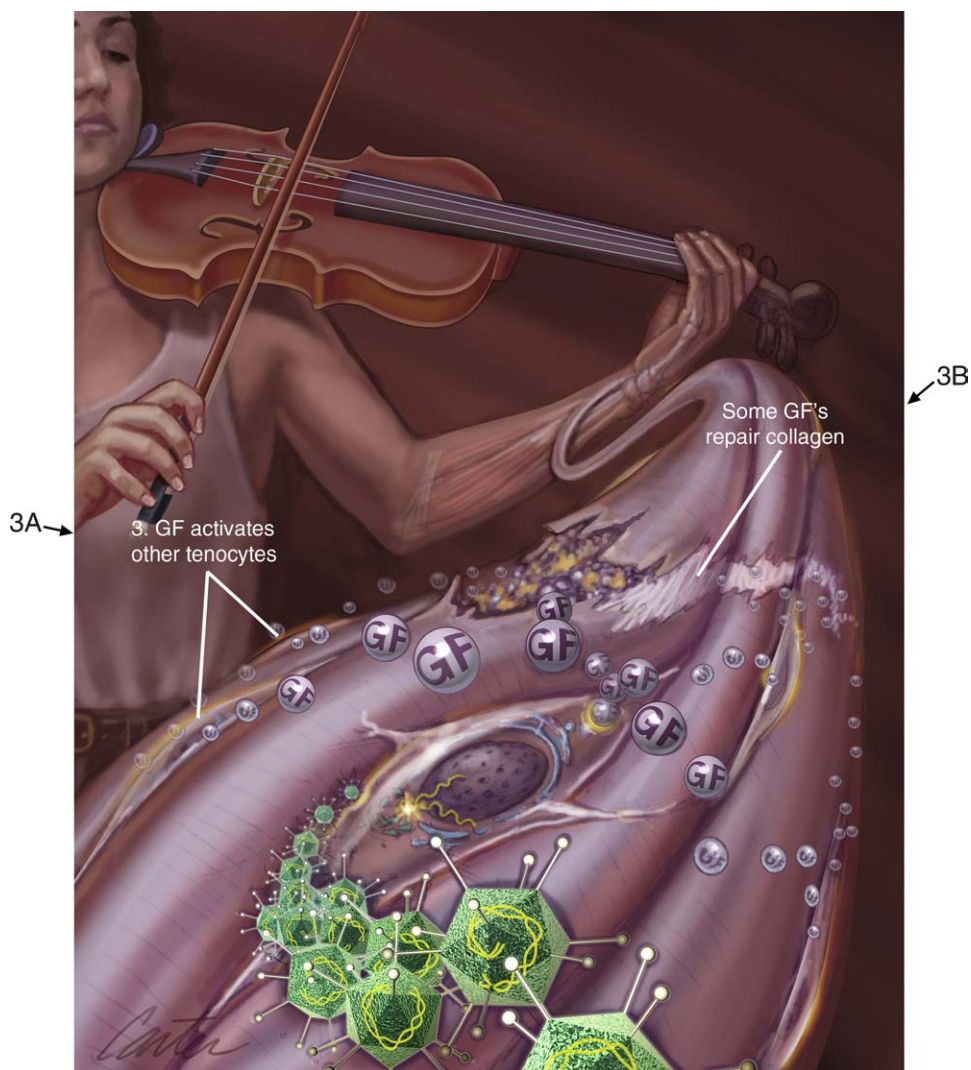


FIGURE 3. (A) Growth factor activates other tenocytes. (B) Some growth factors repair collagen.

418 protocols and the evolution of their
 419 current favored surgical and rehabil-
 420 itation techniques. Their current pre-
 421 ferred splinting technique for flexor
 422 pollicis longus (FPL) repairs includes
 423 immobilizing the fingers with a dor-
 424 sal protective splint that prevents
 425 inadvertent use of the thumb, and
 426 which also may address the problem
 427 of anomalous tendon slips between
 428 the FPL and flexor digitorum profun-
 429 dus to the index. Their techniques
 430 have reduced the high rupture rates
 431 noted in the literature for FPL repairs.
 432 They stress the need for early diag-
 433 nosis, strong repair, early motion,
 434 and movement of the thumb inter-
 435 phalangeal joint.

436 Pettengill⁴⁷ reviews the evolution
 437 of flexor tendon surgery aftercare.
 438 She provides a concise description of
 the various published protocols on
 the management of the repaired

flexor tendons with regard to splint
 geometry, patterns of motion, and
 rationale for the same. Her article
 provides perspective and reminds us
 that although we have available to
 us evidence that allows us some
 parameters for controlling tension
 and excursion at a tendon repair
 site, the art of therapy and the
 human variable remain critical to
 our results.

The study by Groth⁴⁸ was funded
 by the American Hand Therapy
 Foundation Burkhalter Grant 2002.
 She provides us with a survey of the
 current and historical practice pat-
 terns of therapists who treat intra-
 synovial flexor tendon repairs. Her
 personal communication regarding
 the results of this study was as in-
 teresting as the study. She observes
 that most therapists have little auton-
 omy in picking the postoperative

439 protocol for tendon rehabilitation
 440 and that the key to good results is
 441 not in splint design but in the timing
 442 of the exercises and intervention.
 443 She also warns against a technician
 444 mindset and observes that our pro-
 445 tocols have “dummied our art down to
 446 week one, two, and three.” Her sur-
 447 vey clearly demonstrated that many
 448 practitioners are more dependent on
 449 the art of therapy than on its science,
 450 and that they have less autonomy
 than they should at this point in time.

451 Newport and Tucker⁵⁰ update the
 452 available biomechanical and clinical
 453 studies on extensor tendon repair
 454 and implications for postoperative
 455 management. They correlate, in a se-
 456 ries of graphs, the effects of tendon
 457 shortening versus loss of MP and
 458 proximal interphalangeal motion
 459 and the increase in force required to
 maximum digital flexion after tendon

shortening in zone VI. Of clinical interest is their suggestion to splint the MP joints in slight flexion to prevent active tension at a repair site in zones V, VI, and VII with the early motion programs. It would seem that this would be the very reason to splint the MP joints dynamically in full extension, so that some active tension is achieved. They, too, cite the importance of wrist position with splinting and exercise to transmit the appropriate tension to the repair site.

Howell and colleagues³³ have provided us with 20 years of clinical experience and anatomical support for an ingenious method of managing extensor tendon repairs in zones IV–VII. Their program allows for immediate controlled active motion of the repair and greater arcs of motion for adjacent digits. Their splint design is simple and allows greater freedom of movement preventing stiffness in the uninjured adjacent digits. Their results may be unequalled in the world of extensor tendon injuries for patient compliance, functional range of motion, time in therapy, and early return to work. Merritt adds a wonderful perspective in his commentary at the end of the article.

Taras and Silverman⁵¹ review the development and clinical results with the use of nerve conduits for bridging gaps in lacerated peripheral nerves, present their clinical experience, and discuss postoperative therapy considerations. Their article introduces us to new concepts in nerve repair and discusses the potential advantages as compared to nerve grafts.

The next five papers on nerve are rich with anatomical review and remind us of the importance of knowledge of anatomy to proper diagnosis and treatment; and the importance of working as upper extremity therapists, not just as hand therapists. We simply cannot treat the hand properly without treating the elbow, shoulder, and understanding complications from cervical spine dysfunction.

Dell and Sforzo³² revisit the classic work of Richard J. Smith⁵² on ulnar nerve palsy and add a contemporary perspective. They reviews the anatomy, deformities of the ulnar nerve, disorders that limit motion, and considerations for surgical planning. They provides a poignant tribute to

the memory of Dr. Smith and his contribution to the understanding of intrinsic anatomy, reminding us of the importance of mentoring. Dr. Dell is an untiring teacher, and never refers a case without first questioning the therapist about salient points of anatomy, current surgical technique, and expected postoperative protocol. He often makes mention to his fellows and therapists that "anatomy is power."

Kozin⁵³ reviews the functional deficits that result from the loss of both radial and median nerve loss and discusses tendon transfers to restore motor function after a radial or median nerve deficit. He makes a great point: "A bias towards favored techniques is presented as experience lends itself to both good and bad results." His article provides a beautiful review of anatomy, etiology of nerve injury, principal of tendon transfers, and briefly summarizes considerations for therapy.

Pratt²⁸ provides us with an exquisite review of the anatomic features of the most common nerve entrapment sites of the brachial plexus and major peripheral nerves of the upper limb. He describes the various nerves and their course in the upper extremity and potential sites of entrapment, and makes reference to pathological situations at the different levels. Understanding his article is key to clinical evaluation of nerve compression. Again, we are reminded that in medicine "anatomy is power."³²

Novak and Mackinnon²⁹ provide us with an excellent overview of the histopathology of nerve compression, explain the concept of double crush and the effect of neural transmission in upper extremity nerve compression, and review evaluation techniques for nerve dysfunction. They review provocative testing for all levels of compression and the various sensory tests available for patient assessment. Understanding their article, and being able to apply the information that they present, is critical to all upper extremity therapists and surgeons. Those of us who receive referrals from walk in clinics, primary care physicians, and busy orthopaedists know the value of a detailed clinical nerve evaluation at all levels. We owe these two investigators a debt of gratitude for their contributions to our under-

standing of the peripheral nervous system. 517

Walsh⁵⁴ provides an in depth discussion the Upper Limb Neural Tension Test and neural mobilization (NM) and its relationship to neuropathic pain. He reviews current research that supports or refutes the efficacy of testing and treatment, and points out that there is a lack of randomized controlled studies to define clinical application for NM as it applies to dosage, duration, frequency, and amplitude of neural mobilization techniques. His summary of experimental studies on the mechanical properties of the peripheral nerve and the effects of strain, tension and compression make us all the more aware of the subtle stresses that we place on peripheral nerve with some of our therapy techniques and splints designed to stretch and strengthen musculoskeletal tissues. He provides us with treatment principles for the use of NM techniques, and makes the point that "the clinician should integrate basic science and experimental evidence as we work to achieve a sufficient level of confidence in the development of evidence-based practice." This is yet another paper that emphasizes the importance of hand therapists understanding the anatomy of the proximal regions. 518
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Keir and Rempel⁵⁵ review the "physiological, pathophysiological, and histological effects of compressing peripheral nerves in animal models, and then examine the evidence for similar processes in humans using carpal tunnel syndrome (CTS) as a model." A careful read of this article will improve our understanding of intrafascicular pressure and its effect on endoneurial blood flow and improve our appreciation of the delicate nature of peripheral nerve physiology. The clinical implications of external pressure, repetitive loading, vibration, and strain with nerve gliding and stretching can be extrapolated and applied to our daily practice, if for no other reason to be more judicious in our application of force with therapeutic techniques. This paper reviews the effects of duration and magnitude of pressure to ischemia reminding us that brief periods of compression can result in subperineurial edema, and cites experimental research that there may be 550
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little difference in the effects of fluctuating compression versus constant pressure.⁵⁶ The authors also review carpal tunnel anatomy, carpal tunnel pressures as they relate to finger, wrist, and forearm posture, and to finger tip loading, and explain the role of lumbrical incursion. Clinically we see patients postoperative with compressive dressings that are tight enough to cause pressure blisters and transient nerve compression; radial sensory nerve insult from tight casts, ulnar nerve compression from poor operating table position, and increase in medial or ulnar nerve symptoms from static progressive splinting or external fixation with too much traction. We asked Drs. Keir and Remple if we could translate their work to time frames for tolerable compression or tension on peripheral nerve. They state that at this time we only know the short-term pressure-time relationship to changes in nerve function.

Koman was requested to write a paper for hand therapists to improve our understanding of pharmacologic interventions for the treatment of complex regional pain syndrome (CRPS). Li and colleagues⁵⁷ provide an excellent overview of CRPS and discuss therapeutic options for the management of patients with chronic neuropathic or nociceptive pain. Their discussion summarizes clinical evaluation, diagnostic testing, procedures for autonomic control evaluation, and makes the point that the standard of care does not require immediate stellate ganglion blocks for this patient group. They address management issues which include the therapist and emphasize that aggressive passive range of motion is to be avoided. Their discussion of pharmacologic management supplemented with a table defining drug types, classifications, dosage, mechanism and side effects will make for a clearer understanding of the common oral medications for CRPS. It is critical in clinical practice that therapists pick up early sympathetic symptoms and aide the physician with early intervention; it is even more important that we do not impose treatments which cause or aggravate pain or sympathetic symptoms.

Duff³⁰ examines the deficits in sensorimotor control after nerve in-

jury due to changes in the periphery and central nervous system. Her article reviews "motor control issues and neural reorganization concepts that may influence the recovery of skilled prehension following upper limb nerve injury." She provides us with methods to optimize movement strategies by providing supplemental feedback even before regeneration has taken place. She also encourages the clinician to keep abreast of current research on neural regeneration and reorganization. Her work on improving prehensile recovery and sensorimotor control with suggestions for treatment, promises to improve our clinical work with this group of patients.

Michlovitz⁵⁸ provides us with a clinical commentary on the roles of ultrasonography (US) and electrical stimulation (ES) in the rehabilitation for patients with tendon and nerve injury. She reviews contemporary literature with a perspective and bias for clinical evidence of efficacy, and stresses the importance of basing clinical practice techniques with modalities on well designed clinical studies and literature support. She reports that there is no available evidence from well designed clinical trials in humans to support the use of ES to enhance recovery of muscle function or regeneration following axonotmesis or neurotmesis, or for the use of US following tendon repair. She states that there does however appear to be moderate evidence in the literature for the following: US (0.5–1.0 W/cm²) to reduce symptoms of carpal tunnel syndrome,⁵⁹ pulsed US for reducing pain in calcific tendinitis at the shoulder,⁶⁰ and iontophoresis with dexamethasone sodium phosphate for reducing pain in acute tendonitis of the elbow.⁶¹

MacDermid³¹ outlines the current state of affairs for tendon and nerve injury outcome measurement about the hand and wrist and provides recommendations for standards of measurement. She states that "validation of appropriate scales and inclusion of both impairment and disability measures in future clinical studies is required to fully understand how hand therapy impacts on health outcomes following tendon and nerve surgery." She reviews the current assessment tools for tendon and nerve evaluation, the literature

that supports their use, and how current tools and practice relate to the philosophy of the *International Classification of Functioning, Disability and Health*. MacDermid has undeniably been the leader in our discipline in the development of systematic reviews of the literature to help us develop an evidence based practice. She edited the last special issue of the *Journal of Hand Therapy*⁶² on evidence-based practice and has been instrumental in developing instrumentation that will define the evidence that supports or refutes our interventions. Her current work in this issue is supported by a New Investigator Award by the Canadian Institutes of Health Research.

Rosenthal and Stoddard³⁴ close the issue with a solicited "fireside chat" about flexor and extensor tendon management. They were asked to provide us with a series of clinical questions and answers which would summarize the "most frequently asked questions" by hand therapists at their course "Surgical and Therapeutic Management of Flexor and Extensor Tendon Injuries." We wanted their perspective and a learning experience. If you want some quick answers, start here. Their article promises to be the favorite of the issue, and we predict that this teaching style of *clinical commentary by the experts* will become a regular addition in the *Journal of Hand Therapy* by popular demand.

CLOSING COMMENTS

The impact of our profession and that of our individual contributions to our patients is dependent upon our connection with current research, basic science, clinical application, and assessment of outcomes. We hope that these articles will improve your understanding and perspective in the treatment of tendon and nerve, have an impact on your clinical practice, and encourage you to focus as much on *why* as you do on *how*. Experience the joy of learning and the satisfaction of knowing that your connection with basic science and the art of practice will make a difference in lives of the patients you touch.

"And to whomsoever much is given, of him shall much be required;

and to whom they commit
much, of him will they ask
more"

Luke 12:48

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