Joint Denervation

An Atlas of Surgical Techniques

A. Lee Dellon

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A. Lee Dellon
Department of Plastic Surgery and Neurosurgery
Johns Hopkins University
Baltimore, MD
USA

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This book is dedicated to Luiann Olivia Greer, my wife. She has been present for most of my publication preparations, scientific presentations, and the writing of this book. Most importantly, she has helped prepare patients for the surgical procedures described in this book, shared in their history of pain, and their joy of pain relief, in short, bearing witness to the experiences that have created Joint Denervation. I love you Luiann, and it has been such a joy to work with you for the past twenty years.

Lee

Acknowledgments

Thank you to Elaine Lanmon, whose creative talents enabled many of the graphics of this textbook. She turned every clinical photograph into a text-ready format, and transformed sketches into clear examples of what the text demanded. Thank you to Karan Chopra, MD, a Plastic Surgery resident in our Department of Plastic Surgery at Johns Hopkins University, who, interested in our specialty of Peripheral Nerve Surgery, took many of the cadaver photographs used in this book. Finally, thank you to Andreas Gohritz, MD, whom I have known since his Plastic Surgery residency in Hannover, Germany, until his present faculty position at the University of Basel, and with whom I have shared the true academic excitement of rediscovering the history of our specialty, Peripheral Nerve Surgery. His chapter contribution to this text demonstrates his love for translating history.

Preface

A work on anatomy is the most beautiful hymn which a man can chant in honour of his Creator.

Galen [1]

Joint pain was most probably part of the daily existence of *Homo sapiens*, as well as his prehistoric ancestors *Homo erectus*. Even if they did not grow old enough to have osteoarthritis, the way our *Baby Boomer* generation is doing currently, our earliest ancestors surely had post-traumatic joint pain. They most likely ate medicinal herbs and lived with the pain.

Today, joint pain is considered largely a problem whose origin is ligamentous, cartilaginous, and bone. Today, when complete osteocartilaginous-ligament reconstruction has been completed, persistent pain becomes the province of physical therapy and drugs. This is, in large part, the etiology of the physician-induced, modern-time, opioid addiction epidemic.

Today, orthopedic surgeons, podiatric foot and ankle surgeons, plastic and orthopedic hand surgeons, and neurosurgeons participate with traditional and interventional pain management physicians and rehabilitation medicine physicians in the acute and chronic care of those worldwide with joint pain. *The population of joint pain patients probably exceeds numerically those with migraine headaches and diabetes.*

It is a goal of this book, Joint Denervation: Anatomic Atlas of Surgical Technique, to educate the world of physicians caring for patients with chronic joint pain to know that this pain is ultimately transmitted, if not derived, from a peripheral nerve.

A *neural origin for joint pain* was postulated in the mid-nineteenth century, in Bavaria. The professor of Anatomy at the Ludwig Maximilian University in Munich, Nikolaus Rüdinger (1832–1896), did this work as his PhD thesis. It was published in German with the title *Die Gelenknerven des menschlichen Körpers* [2]. This title translates as "The Articular Nerves of the Human Body." It was published in 1857 by Ferdinand Enke Erlangen (Fig. 1).

This amazing pioneering work might have laid the foundation for modern partial joint denervation were it not for the obscurity of this doctoral thesis and its line drawings of the tiny articular nerves. Among the joints described by Rüdinger are the temporomandibular, shoulder, elbow, wrist, finger, sacroiliac, hip, knee, ankle, and first and second metatarsophalangeal [3].

There was then, in the nineteenth century, an almost complete lack of interest in the innervation of joints (see Chap. 1 on History). Then Albrecht Wilhelm entered the scene as a young anatomy assistant, again, at the Ludwig Maximilian University. Wilhelm discovered Rüdinger's writings and illustrations, and he expanded upon them in publications in 1958, 1963, 1965, 1966, and 1972 [4–9]. However, all his writing was in German, and Wilhelm's work did not receive the credit it deserved due to the relative obscurity of his publications.

Wilhelm did develop the concept of *total denervation of the wrist.* This required four incisions and resecting ten separate distal nerve branches (see Chaps. 3, 4, and 5 on the Wrist). Professor Dieter Buck-Gramcko of Hamburg, Germany, published in 1977 in the second issue of the *Journal of Hand Surgery* (American Edition) in English, the "German Speaking People's Results of 300 Total Wrist Denervations," thus bringing wrist joint denervation to modern attention [10].

The advantages of joint denervation are as follows:

1. Relieves pain while preserving the joint.
2. No implants are needed.
3. Immediate joint function is possible.
4. Surgery can be done in an outpatient facility.
5. Reduced cost compared to joint fusion or replacement.
6. Future joint fusion or replacement is still possible.

The *evolution of joint denervation from "total" to "partial"* has enabled the application of relief of joint pain by interrupting the pain pathways. In 1978, A. Lee Dellon, MD, described accurately the location of the nerve to the dorsum of the wrist joint, the posterior interosseous nerve [11], and then, in 1984, described the location of the anterior interosseous nerve [12]. In both situations, traditional anatomy books illustrated these nerves ending once they had innervated a muscle, but, in reality, these nerves continued distally to innervate the joint capsule. Dellon's approach—of first doing a nerve block to identify that a given nerve contributes to the pain and that (with the block in place) the patient had greater use of that joint function without pain—formed the basis of what would become an extension of the principle of partial joint denervation to many other upper and lower extremity joints, and this has been reviewed [13–15]. Dellon went on to describe the innervation and then the denervation of the temporomandibular joint [16, 17], lateral [18, 19] and medial humeral [20, 21] epicondyles, shoulder [22, 23], knee [24–26], and ankle [27–29].

The critical need for this book becomes clear when it is realized that there is not one anatomy textbook extant that illustrates the innervation of any joint in the human body other than zygapophyseal joints of the vertebral column.

The basic anatomy dissections done by Dellon appear in a myriad of different medical journals, making it very difficult for a doctor to learn the exact location of the nerves innervating the joints, making it difficult to learn the operative approaches, and making it a challenge to learn the evidence base of the surgical outcomes of partial joint denervation. This is somewhat similar to the problem that Wilhelm created when he published all his early papers in the German language. Each chapter in this textbook, therefore, except the one on the History of Joint Denervation, will include the anatomy relevant to the joint discussed, the surgical approaches, and conclude with the available current evidence supporting partial or total denervation of that joint.

It is the purpose of this book to make the knowledge of how denervation can relieve joint pain available to the many groups of physicians who care for this problem. The listing of these doctors appropriately begins with those physicians involved with the frontline care of people with chronic joint pain, such as the *sports medicine physicians; the interventional pain management physicians, including physical medicine and rehabilitation; radiologists; and anesthesiologists.* While not considered traditional in terms of surgical intervention, these groups of doctors—using imaging that includes X-ray, CT, MRI, and ultrasound to do the nerve blocks—then can continue with forms of radiofrequency intervention and hydrodissection. Once traditional medical care no longer is relieving the pain, surgical intervention is possible by *oral maxillofacial surgeons and craniofacial surgeons for the temporomandibular joint, by orthopedic and podiatric foot and ankle specialists for the lower extremity, by both orthopedic and plastic surgery-trained hand surgeons, and, finally, by plastic surgeons and neurosurgeons who are trained to operate on both upper and lower extremities.*

To facilitate the preparation of this book, it was decided to create an environment in which this anatomic knowledge could be rediscovered and reconfirmed. This was accomplished during a workshop at the Mayo Clinic, in Rochester, Minnesota, in August 23–25, 2017 (Figs. 2 and 3). The workshop was co-directed by Richard A. Berger, MD, PhD, Director of Hand Surgery in the Orthopedic Surgery Department at the Mayo Clinic; by his successor Marco Rizzo, MD; by Robert J. Spinner, MD, Chief of Neurosurgery at the Mayo Clinic; and by A. Lee Dellon, MD, PhD, Professor of Plastic Surgery and Neurosurgery at Johns Hopkins University in Baltimore, Maryland. Human prosessections were created and photographed Karan Chopra, MD, Plastic Surgery resident, Johns Hopkins Hospital, to be incorporated into this text. To the extent that we were successful, only you and future students of joint denervation will judge.

Baltimore, MD, USA A. Lee Dellon

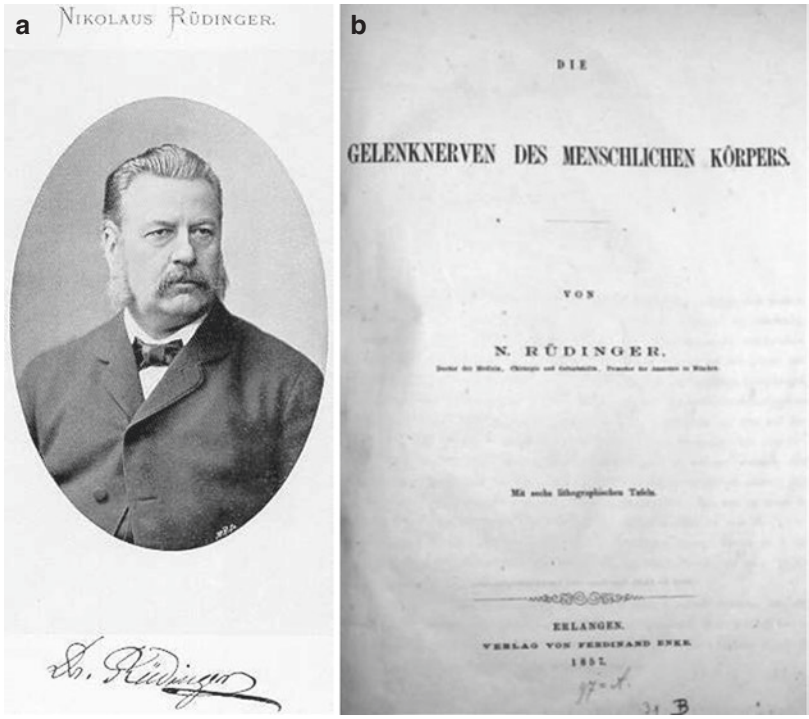

Fig. 1 (**a**, **b**) Nikolaus Rüdinger (1832–1896). Photograph (**a**) and Frontispiece from his PhD Thesis (**b**). (Source: Rüdinger [2]. Public Domain)

Fig. 2 Faculty and attendees at the first ever workshop on joint denervation held at the Mayo Clinic in Rochester, Minnesota, in August 2017

Fig. 3 (**a**–**d**) Joint Denervation Workshop. (**a**) Workshop title. (**b**) Prossection Instructors: left to right are Eric H. Williams, MD, A. Lee Dellon, MD, PhD, and Timothy W. Tollestrup, MD. (**c**) Virginia Hung, MD, attending from Massachusetts, did a Peripheral Nerve Fellowship with Dr. Dellon after her Plastic Surgery and Hand Fellowship. (**d**) Nho (Bill) Tran, MD, Plastic Surgeon at the Mayo Clinic, Dr. Dellon, and Co-Director of the Workshop, Robert J. Spinner, MD, Chief of Neurosurgery at the Mayo Clinic

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Contents

Contributors

A. Lee Dellon Department of Plastic Surgery and Neurosurgery, Johns Hopkins University, Baltimore, MD, USA

Andreas Gohritz University Hospital, Basel, Switzerland

Swiss Paraplegia Center, Switzerland

Historical Perspective on Joint Denervation

1

Introduction

Joint denervation can be defined as a surgical transection of afferent joint pain fibers transmitting pain to the brain. Denervation offers the promise to preserve or improve joint function and is an alternative in painful osteoarthritis to more destructive surgical procedures, such as arthrodesis or resection arthroplasty with endoprostheses. The potential of denervation had to be based on the demonstration that afferent nerves of the joints exist, as these nerves essentially are absent from all standard anatomy texts.

This chapter highlights the history of surgical joint denervation with its main protagonists.

Nikolaus Rüdinger (1832–1896): First Description of Joint Innervation

It was the anatomist Nikolaus Rüdinger (1832–1896) (Fig. 1.1) in Munich, who, in 1857, meticulously described in his doctoral thesis "The articular nerves of the human body." [1]

Nikolaus Rüdinger was born in 1832 as the last of 12 children of a farmer and butcher who died when Rüdinger was only 3 years old. After working as an apprentice barber from age 14 until 18, Rüdinger found employment as anatomy assistant in Tübingen and could study medicine for 4 years due to a small inheritance. Theodor Bischoff (1807–1882), chairman of anatomy in

Fig. 1.1 Nikolaus Rüdinger (1832–1896): Apprentice barber, military surgeon, anatomy professor, and first describer of "The Joint Innervation of the Human Body" (1857). (Source: Rüdinger N. Die Gelenknerven des menschlichen Körpers. Erlangen: Ferdinand Enke; 1857. Public Domain)

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Giessen, recognized Rüdinger's extraordinary talent for anatomical dissection and offered him a job as prosector. Rüdinger thus rejected his original plan to immigrate to Russia and to work as a war surgeon in the Crimean War, and he followed his mentor to Munich, where he wrote his medical thesis in 1857 on the joint innervation. Rüdinger's further academic career was characterized by his unwavering persistence despite numerous setbacks: the Bavarian authorities rejected his request for "habilitation" four times until 1864 because Rüdinger did not have a Bavarian school exam and his period of study was regarded as too short. In spite of his widely acclaimed research, he became adjunct only by royal decree and after personal intercession of Justus von Liebig (1803–1873) in 1868, and, in 1870, he was appointed by King Ludwig II of Bavaria himself as associate professor. In the Franco-German War of 1870–1871, Rüdinger was honored as military surgeon. Only after the death of von Bischoff in 1882 did he acquire the position of full professor and curator of the Anatomical Institute and its collection and become the Chair of Anatomy at the Ludwig-Maximilian University in Munich [2]. In 1886, Rüdinger performed the autopsy and subsequent embalming of his generous mentor, King Ludwig II of Bavaria (1845–1886). Contrary to conspiracy theories claiming until today that Ludwig II was murdered, Rüdinger noted in his autopsy report: "Nowhere are injuries on the body surface, in particular, no injuries to the neck or facial skin noticeable." [3] Rüdinger died in 1896 of appendicitis.

Rüdinger's medical thesis and first publication in 1857 was entitled "The Articular Nerves of the Human Body." [1] It was dedicated to the entire joint innervation in the human body including the temporomandibular joint; the shoulder, the elbow, the wrist, and the finger joints in the upper extremity (Fig. 1.2); the sternoclavicular joint; the sacroiliac; and the hip, the knee, the ankle (Fig. 1.3), and the first and second toe joint in the lower extremity. Overall, Rüdinger wrote about 90 academic papers. He introduced drawings from photographs, taken by the Bavarian court photographer and inventor of light printing, Joseph Albert (1825–1886), in an anatomy atlas, probably for the first time ever. "The cooperation of the principal prosector of his time with an artistic breakthrough photographer [...] celebrated a triumph that has not been exceeded and Rüdinger's name shined wherever anatomists worked and taught": this was written in his obituary of 1897 [2]. Rüdinger was highly talented manually and technically skilled; he invented injections of carbolic acid mixed with glycerine and alcohol for the preservation of human cadavers and enriched the Anatomical Collection with many unique dissections and personal drawings and engravings, such as those of the inner ear and the peripheral nervous system (Fig. 1.4). Like the founder of modern Russian surgery, Nikolai Pirogov (1810–1881), he used slices of frozen corpses as early forms of imaging. Famous among students (and personally known to the author) was his unique plastic paper-maché model of the trunk in eight sagittal slices, called "sliced-Tony" ("Scheibentoni"), which unfortunately was lost a few years ago (Fig. 1.5). Rüdinger was trained as a surgeon and obstetrician, but as far as we know, he never operated on any patient with joint pain.

John Hilton (1805–1878): Hilton's Law (1863)

Hilton's Law (1863) is familiar to most anatomists: "The same trunks of nerves whose branches supply the groups of muscles moving a joint furnish also a distribution of nerves to the skin over the insertions of the same muscles; and—what at this moment more especially merits our attention—the interior of the joint receives its nerves from the same source." As "one of the most useful and celebrated axioms in clinical anatomy," it reliably describes the nerves that can contribute to the complex innervation of joints [4].

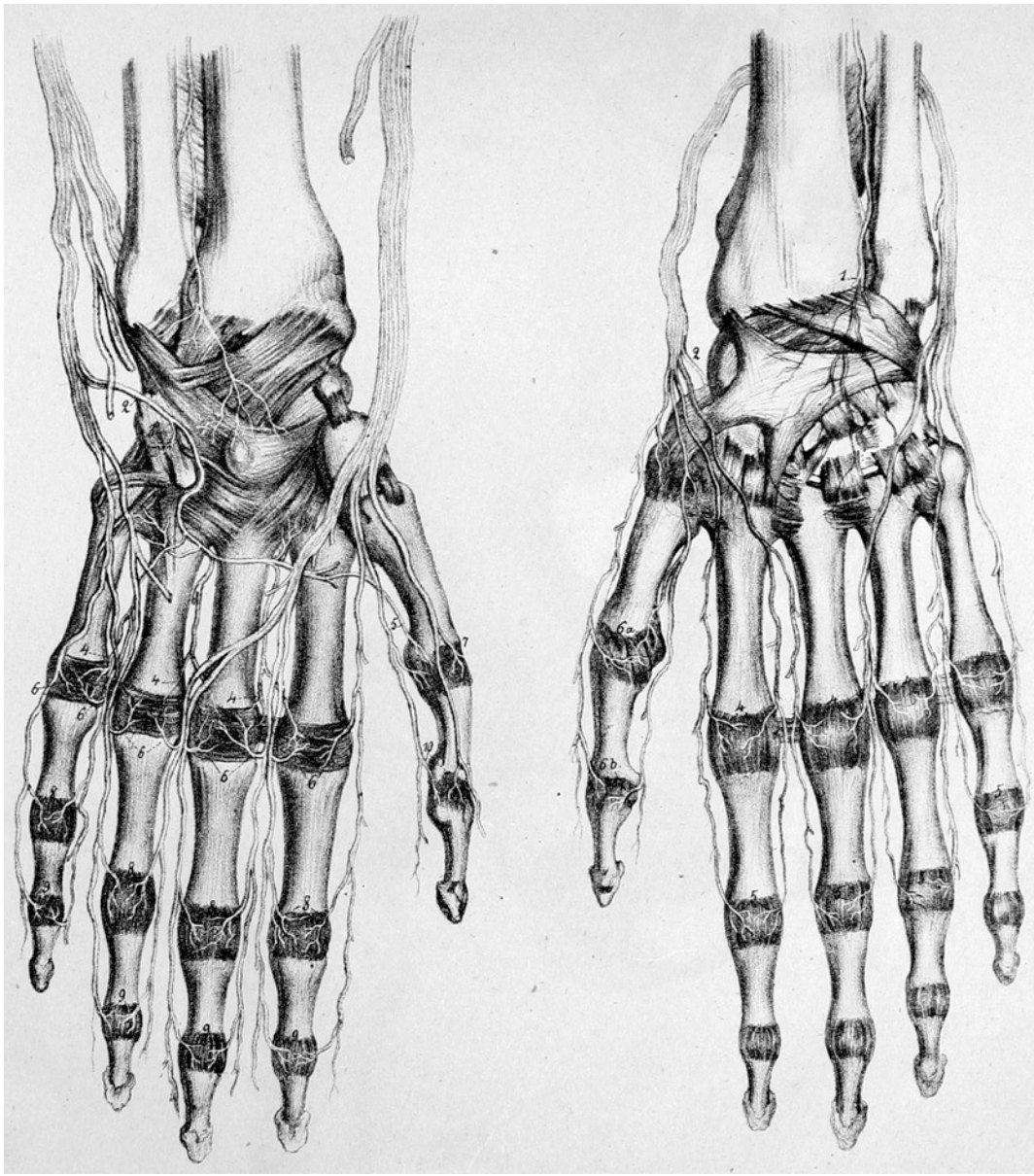

Fig. 1.2 Innervation of the wrist according to Rüdinger (1857). (Source: Rüdinger N. Die Gelenknerven des menschlichen Körpers. Erlangen: Ferdinand Enke; 1857. Public Domain. Bayerische Staatsbibliothek München/4 Anat. 157 s, Tab. 3 urn:nbn:de:bvb:12-bsb10331108-1)

"Total" Joint Denervation

Several decades after Rüdinger's discovery in 1857, the Swedish surgeon Helge Camitz in 1933 developed the idea to treat painful adduction contracture of the hip by obturator neurotomy, yet primarily in order to treat the muscle imbalance, not pain due to osteoarthritis (Table 1.1) [5]. This approach proved only moderately successful but was improved in 1942 by Tavernier after new

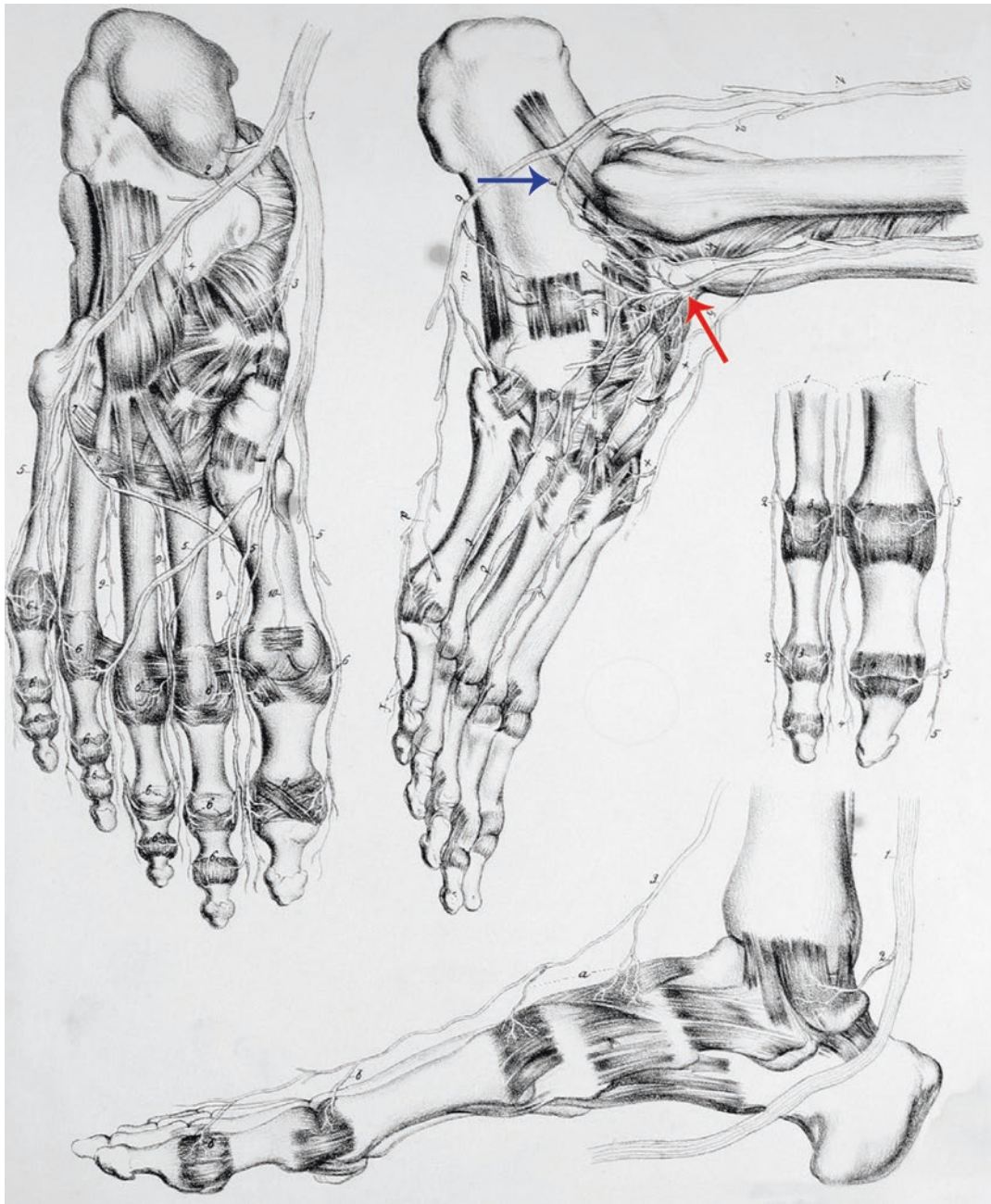

Fig. 1.3 Innervation of the ankle according to Rüdinger (1857). (Source: Rüdinger N. Die Gelenknerven des menschlichen Körpers. Erlangen: Ferdinand Enke; 1857. Public Domain. Bayerische Staatsbibliothek München/4 Anat. 157 s, Tab. 5, urn:nbn:de:bvb:12-bsb10331108-1)

anatomical studies of the hip joint innervation [6]. The principle was subsequently transferred to other joints with varying success, including the knee joint by Marcacci 1954 [7], the shoulder joint by Nyakas and Kiss 1955, and the ankle joints [8], also, by Nyakas in 1958, who introduced preoperative procaine nerve blocks to test the likelihood of success of a neurotomy which increased the reliability of denervation procedures [9].

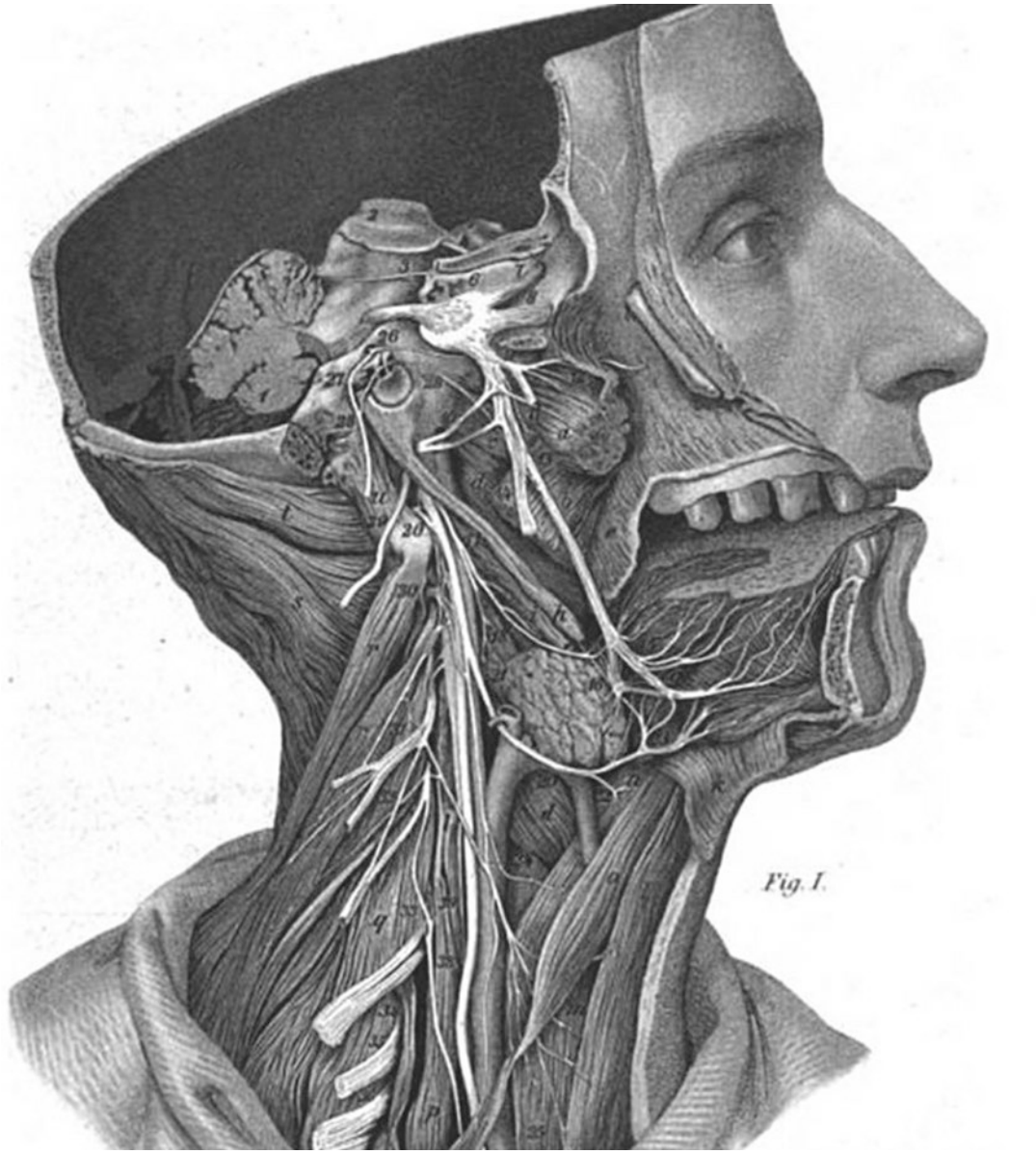

Fig. 1.4 Drawings by Rüdinger of the cranial nerves and facial nerves after photographs taken by the royal court photographer Joseph Albert (1825–1886). (Source: Rüdinger N. Die Gelenknerven des menschlichen Körpers. Erlangen: Ferdinand Enke; 1857. Public Domain. Bayerische Staatsbibliothek München/4 Anat. 157 s, Tab. 1, urn:nbn:de:bvb:12-bsb10331108-1)

Albrecht Wilhelm (1929–2017)

The German surgeon Albrecht Wilhelm (Fig. 1.6) worked as a mostly unpaid anatomy assistant in the late 1950s at the Anatomical Institute in Munich (Fig. 1.7) before starting his surgical training. He worked there under the direction of Prof. Titus Ritter von Lanz (1897–1967) (Fig. 1.8) who gave him the task to study upper extremity innervation for his famous work "Practical Anatomy: A

Fig. 1.5 Rüdinger's innovative three-dimensional papier-maché model of the human trunk called "Scheibentoni" (sliced-Tony): the head and neck were presented in eight sagittal slices devised after slices sawn from frozen human bodies, a prerunning technique of modern tomography. (Courtesy of Dr. Erich Kaiser)

Table 1.1 Chronology of the development of surgical joint denervation

Year	Author	Contribution
1857	Rüdinger (Germany)	First description of "The Joint Innervation of the Human Body"
1863	Hilton (England)	Hilton's Law explaining complex joint innervation patterns
1933	Camitz (Sweden)	Idea of cutting the obturator nerve in painful hip adduction to treat contracture—not pain from osteoarthritis (only modest success)
1942	Tavernier (France)	Improved pain reduction after hip denervation following specific anatomical studies
1954–1958	Nyakas (Hungary)	Publication on ankle denervation (after test nerve block)
1955–1956 1959	Wilhelm (Germany)	Rediscovery of upper extremity joint innervation as the basis of surgical joint denervation, First wrist denervation (radiocarpal arthritis) in Würzburg
1962–1966	Wilhelm (Germany)	Joint denervation as "A new concept in hand surgery"
1984–to date	Dellon (USA)	Anatomical and clinical studies on new denervation techniques in wrist, shoulder, elbow, knee, ankle, temporomandibular joints

Fig. 1.6 Albrecht Wilhelm (1929–2017), who published *Surgical Joint Denervation: A New Concept in Hand Surgery* in 1966 and became the protagonist of the concept of "total wrist denervation." (Courtesy of Professor Ulrich Lanz)

Fig. 1.7 Anatomische Anstalt in München, "birthplace" of joint innervation and upper extremity joint denervation. Albrecht Wilhelm worked here from April 1955 until May 1956 as assistant under the guidance of Professor Titus Ritter von Lanz. (Source and Copyright by Stadtarchiv München, Winzererstraße 68, Munich, Germany)

Manual for Physicians and Surgeons." Wilhelm found Rüdinger's book in the institute's library with handwritten commentaries and drawings and first wanted to abandon his own investigations. After Wilhelm realized that he had discovered important new details complementing Rüdinger's studies significantly, he published on the entire upper extremity innervation in 1958 [10]. He continued by introducing in 1963 [11] and 1966 [12] methods of denervation of the shoulder, wrist, and finger joints. His meticulous anatomical studies proved that neurotomy of articular branches was possible without causing sensory loss or paralysis by damaging sensory or motor branches of the hand and provided the basis for reliable denervation procedures in the upper extremity. For the wrist, he described "total wrist denervation" and reported an initial pain relief in 80% of cases, and after an average of over 10 years, pain relief remained well above 60% [13, 14]. Although total joint denervation had proven beneficial for wrist pain, it was not employed frequently, probably due to the demanding operative technique to selectively cut ten afferent pain branches, while not treating the underlying disease. Another obstacle to more universal acceptance was that Wilhelm's early publications were mostly in German. The German-speaking experience in total wrist denervation (in more than 300 cases) was published in English in the second issue of the *Journal of Hand Surgery* by Buck-Gramcko in 1977 [15]. Wilhelm extended his upper extremity denervation approach to lateral humeral epicondylitis, in which he not only denervated the lateral humeral epicondyle but also the radiohumeral joint [16]. Recently, shortly before his death in 2017, he summarized his life's work on denervation of the shoulder, elbow, wrist, and hand joints and other controversial pain problems in the upper extremity, such as proximal irritation and compression of the radial nerve, humeral epicondylitis radialis, thoracic outlet syndrome, and complex regional pain syndrome, which he treated by transaxillary decompression. [17] Notably, Wilhelm, later at Würzburg University, trained the son of his mentor Titus Ritter von Lanz, Ulrich Lanz (*1940) [18], who became a leading figure of contemporary hand surgery in Germany and who co-authored two very influential books: *Anatomy of the Hand* and *Diagnostic Imaging of the Hand* (Fig. 1.9).

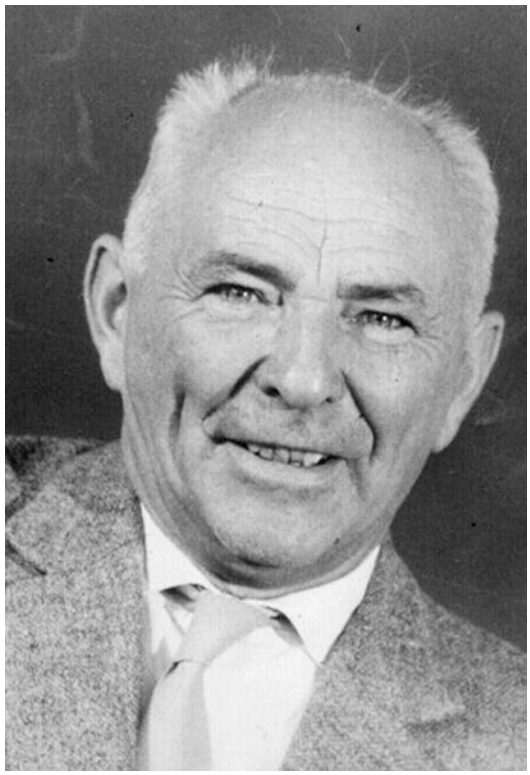

Fig. 1.8 Titus Ritter von Lanz (1897–1967), author of the monumental work on *Functional Anatomy*, including the famous volume on *The Arm* (1959). (Courtesy of Professor Ulrich Lanz)

Fig. 1.9 Albrecht Wilhelm (right) discussing with his surgical disciple Ulrich Lanz (*1940), who became a leading authority in hand surgery in Germany. He co-authored two classic books on *Anatomy of the Hand* and *Diagnostic Imaging of the Hand* and trained many hand surgeons in his country. (Courtesy of Professor Ulrich Lanz)

Elbio Cozzi (1926–1984)

Independently, Cozzi from Argentina dissected the amazing number of more than 500 hands between 1961 and 1980 to study the innervation of the principal joints, above all the metacarpophalangeal joint of the thumb. The results of his anatomical investigations and surgical operations were published in French and then English only posthumously by Tubiana [19].

Surgeons in France, led by Guy Foucher, followed and enthusiastically accepted Wilhelm's approach [20]. Foucher and his students, such as Loréa, applied this approach to the carpal, metacarpal, and proximal interphalangeal joints [21–23]. They agreed on contraindications for joint denervation, the most common reason for failure being joint instability.

"Partial" Joint Denervation

In 1978, the year after Buck-Gramcko's classic paper on total wrist denervation in which portions of the wrist joint were denervated by passing the electrocautery several times across the distal bone/ligament, Dellon and Seif clearly described the exact anatomic location of the posterior interosseous nerve in the radial side of the fourth extensor compartment [24], permitting an approach to partial dorsal wrist denervation that was reported in 1985 [25].

In 1984, Dellon and co-workers identified the anatomic location of the anterior interosseous nerve entering the volar wrist ligaments, permitting a partial palmar wrist denervation approach [26]. Later, Richard Berger's group from the Mayo Clinic in Rochester confirmed the success of this partial approach to wrist denervation [27, 28]:

The major difference between total and partial wrist denervation is that by pre-operative local anesthetic block of individual peripheral nerve joint afferents in known anatomic locations, relief of pain and improved function prior to surgery can be demonstrated, reducing the need for multiple incisions and almost total joint deafferentation.

The concept of partial wrist joint denervation was extended to other joints by a sequence of research that first required anatomic dissection of fresh cadavers using loupe magnification and then a clinical series requiring local anesthetic blockade to demonstrate pain relief and improved function. Historically, this was extended by Dellon and co-workers in 1994–1996 to the knee [29–31], in 1996–2004 to the shoulder [32, 33], in 2001–2005 to the ankle [34–36], in 2003–2006 to the temporomandibular joint [37, 38], in 2006 to the medial humeral epicondyle [39], in 2011 to the lateral humeral epicondyle, [40] and in 2014 to the ulnar side of the wrist joint, including the triangular fibrocartilaginous complex (TFCC) [41]. These studies have been reviewed recently [42, 43] and are now included in textbooks for plastic surgery and upper and lower extremity surgery specialists [44–47].

In 2017, Dellon organized the first international instructional course on "Surgical Joint Denervation" at the partial Mayo Clinic in Rochester (Fig. 1.10).

Discussion

A comparison of today's modern techniques and studies by Rüdinger on joint denervation shows remarkable similarities. The exact description of the nerve supply by Rüdinger, however, did not mention frequencies or variability. The successors of Rüdinger's studies have confirmed his main points, added important operational details, and used different anatomical terminologies. Ultimately, the description of the joint innervation by Rüdinger, although he probably never intended this, became the foundation and stimulus that initiated surgical techniques for surgical joint denervation.

Today, the trend is clearly moving toward partial joint denervation in the treatment of chronic joint pain for which other surgical alternatives would be more destructive. The emphasis is toward understanding the role of these afferents in addition to the obvious one of nociception. While a "Charcot"-type joint cannot occur from partial denervation, the continued histologic demonstra-

Fig. 1.10 Arnold Lee Dellon, MD, PhD (2nd from left), the pioneer of techniques of "selective joint denervation," teaching surgeons at the international instructional course on "Surgical Joint Denervation" at the Mayo Clinic, Rochester, in August 2017. Dellon is standing with, from the left, Thomas Gohla, MD, from Karlsruhe, Germany; Andreas Gohritz, MD, from Basel, Switzerland; and Andreas Steiert, MD, from Berlin, Germany

tion of slowly and quickly adapting sensory end organs within ligaments [48] raises the question as to whether a significant proprioception or tendon balance reflex would be inhibited by such a joint denervation [49, 50]. Most likely, no significant detrimental effect occurs from partial joint denervation, [51, 52] *and it may be inferred that this approach will be refined to more joints in both the upper and lower extremities, as long-term success rates up to 80% have been reported* (Table 1.1).

Recently, considering that the approach of "joint denervation" has been applied to portions of bone that are not truly a joint, such as the humeral epicondyles, it is not surprising perhaps that it has recently been applied to other sports injuries with a similar mechanism of chronic tears, such as the groin pull [28].

A greater interest in the modern possibilities of surgical joint denervation has increased the number of patients who could benefit from this treatment, which was stimulated by Rüdinger's legacy and the work of surgical pioneers, such as Wilhelm, Cozzi, and Dellon.

Until today, new clinical series continue to be published by authors with plastic and orthopedic surgery backgrounds and have confirmed the great benefit both for patients in the upper and lower extremity and for their treating surgeons [53–57].

The time of surgical joint denervation arrived!

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