Dupuytren's Contracture

Leon S. Benson, MD, Craig S. Williams, MD, and Marjorie Kahle, OTR/L

Abstract

Dupuytren's contracture is a fibroproliferative disorder of autosomal dominant inheritance that most commonly affects men over age 60 who are of Scandinavian, Irish, or eastern European descent. Local microvessel ischemia in the hand and specific platelet-derived and fibroblast growth factors act at the cellular level to promote the dense myofibroblast population and altered collagen profiles seen in affected tissue. Surgical treatment depends to some degree on patient preference and a clear understanding of the possible complications and considerable postoperative therapy commitment. Operative management is appropriate when metacarpophalangeal or proximal interphalangeal joint contracture exceeds 30 degrees. A volar zigzag Brunner incision in the digit and palm provides reliable exposure and leads to predictable healing in most cases. The mainstay of postoperative hand therapy is early active-flexion range-of-motion exercises to restore grip strength. A nighttime extension splint is often used for several months postoperatively to maintain the correction achieved in the operating room. Early recurrence of disease is most common in individuals with Dupuytren's diathesis; use of full-thickness skin grafts may be helpful for these patients.

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The first description of Dupuytren's disease has been credited, not to Guillaume Dupuytren, but to Felix Plater of Basel, Switzerland (1536-1614).[1] Plater's description of palmar fibromatosis was published in his book cataloguing autopsy findings (*Observationum in Hominis Affectibus*, published in 1614). Plater described the case of a stonecutter who sustained a severe traction injury to the small finger and subsequently presented with a fixed flexion contracture of the digit. This case has been cited as the first record of Dupuytren's disease, probably because Plater's description focused on the progressive contraction of affected digits into the palm and the appearance of palmar skin ridging. It is interesting to note, however, that careful translation of Plater's original Latin manuscript has been thought to describe a traumatic rupture of the flexor pulley system.

Henry Cline (1750-1826), a surgeon at London's St. Thomas Hospital, also contributed to the documentation of palmar fibromatosis before Dupuytren's publications. Most of Cline's work was not published formally but was recorded by the note taking of his pupils. During one of his lectures in 1808, Cline clearly described the characteristic anatomy of the palmar aponeurosis, noting that it "sometimes becomes contracted and thickened."[2] Cline went on to describe the typical contracted appearance of the fingers and recommended surgical release of the tightened palmar aponeurosis. He also noted that the close proximity of nerves and arteries required meticulous surgical technique and that postoperative care was facilitated by use of an extension splint for the fingers.

One of Cline's apprentices was Astley Cooper (1768-1841). Cooper also described palmar fibromatosis prior to Dupuytren's formal writings (by about 10 years). In Cooper's book, *A Treatise on Dislocations and Fractures of the Joints*,[2] published in 1822, he noted that a chronic inflammation of the palmar aponeurosis produces finger contractures. Cooper speculated that repetitive trauma might be a causative factor and that surgical release of contracted fibers should be performed by means of a percutaneous fasciotomy.

Dr. Benson is Assistant Professor of Clinical Orthopaedic Surgery, Northwestern University Medical School, Chicago. Dr. Williams is Assistant Professor of Clinical Orthopaedic Surgery, Northwestern University Medical School. Ms. Kahle is Senior Occupational Therapist, Glenlake Hand Therapy, Glenview, Ill.

Reprint requests: Dr. Benson, Suburban Orthopaedic Associates (subdivision of Illinois Bone and Joint Institute, Ltd), Suite 300, 3633 West Lake Avenue, Glenview, IL 60025.

Guillaume Dupuytren (1777-1835) was one of the giants of surgery for more than 30 years, from the end of the 18th century through the early 19th century. He was a brilliant physician-scientist, a captivating lecturer, and a demanding, egocentric personality.[3] While he was Chief Surgeon of the Hôtel Dieu in Paris, he published a description of two patients with palmar fibromatosis in 1834.[1] Dupuytren's writings reiterated many points of those before him, including Cooper's theory that the contracture was a result of overuse or trauma. Dupuytren's name likely became affixed to the disease for a variety of reasons, not the least of which was his stature as the most famous surgeon in Europe at the time. Dupuytren's publications described not only the anatomic pathology but also the clinical presentation, natural history, surgical technique, postoperative care, response to treatment, and long-term follow-up.

Basic Science

Although it was once thought that a particular cell type was uniquely responsible for Dupuytren's disease, it is now clear that the two key cell types present in the diseased fascia, the fibroblast and the myofibroblast, are not unique to this condition. The myofibroblast has received particular attention as possibly the histologic hallmark of Dupuytren's contracture; however, detailed electron-microscopic studies have shown that these myofibroblasts, which share characteristics of both typical fibroblasts and smooth muscle cells, are not ultrastructurally different from those identified in normal tissues elsewhere in the body, such as the umbilical cord, small intestine villi, and pulmonary alveoli.[4] In Dupuytren's disease, the myofibroblast is also located in palmar fascial nodules.

Biochemical characteristics have also been carefully examined. A study of 10 major metabolic enzymes and 7 lysosomal enzymes of fibroblasts in tissue from patients with Dupuytren's disease showed a higher total activity level compared with those in normal tissue.[5] However, when the higher density of cells in the diseased tissue was taken into account, the enzyme activity per cell was not different from that in normal tissue.

Collagen chemistry research has shown that Dupuytren's fascia contains much higher concentrations of type III collagen, a higher ratio of type III collagen to type I collagen, increased amounts of total collagen, and increased lysyl oxidase activity.[4] However, subsequent studies that took into account the increased cell density of the tissue demonstrated that the pattern of collagen production could be related almost entirely to increased density of cells and not to any specific intrinsic biochemical behavior of an "abnormal" fibroblast.[4] Even the higher concentration of glycosaminoglycans found in the collagen has been shown to be proportional to the increased number of cells present.[4]

The high cellularity seen in Dupuytren's tissue may be caused by local ischemia at a microvascular level. Most of the abundant fibroblasts in Dupuytren's tissue are clustered around partially or totally occluded microvessels. A similar pattern of fibroblast aggregation has been identified in the local ischemia seen in diabetic patients.[4] Furthermore, a study comparing lipid composition in affected hands with that in normal hands showed that the fascia in the former displayed a lipid profile consistent with mild local tissue hypoxia.[6] It is therefore postulated that the pathogenesis of Dupuytren's contracture is related to local ischemia, which stimulates increased production of fibroblasts and related cell types. The fibroblasts tend to organize themselves along lines of mechanical stress, eventually creating typical cord-type arrangements of palmar fascia. All of the subsequent physical and chemical characteristics of Dupuytren's tissue are a direct result of this increased population of fibroblasts. The exact mechanism of how ischemia stimulates fibroblast production has been tied to the production of oxygen free radicals that occurs in hypoxic tissue.

Local microvessel ischemia can be the result of genetic, age, gender, or environmental factors, many of which are already known to be associated with the presentation of Dupuytren's disease. For example, alcohol consumption, cigarette smoking, and human immunodeficiency virus infection are all associated with Dupuytren's disease in varying degrees. All of these conditions may be linked to Dupuytren's contracture through their ability to increase production of oxygen free radicals. A self-perpetuating cycle can develop, as fibroblast strangulation of microvasculature further increases local ischemia, which then additionally increases fibroblast production and elevates the concentration of oxygen free radicals (Fig. 1).

Myofibroblast proliferation has been shown to be responsive to specific protein factors that operate at a cellular level.[7] Platelet-derived growth factor and basic fibroblast growth factor have been shown to stimulate cell growth.[7-9] A third protein, transforming growth factor B, has been shown to be a powerful stimulator of collagen produc-

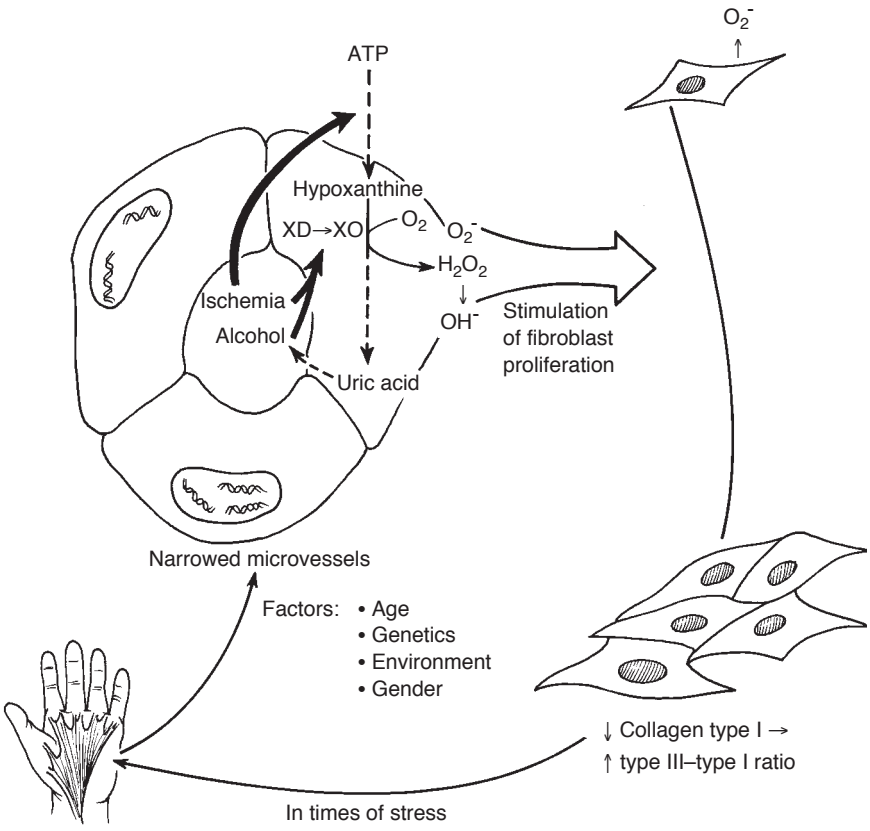

Fig. 1 Schematic depicting Murrell's theory of the pathogenesis of Dupuytren's contracture, illustrating the role that local microvascular ischemia plays in stimulating fibroblast proliferation.[4] ATP = adenosine triphosphate; XD = xanthine dehydrogenase; XO = xanthine oxidase.

tion.[10] It has been proposed that Dupuytren's cells are more sensitive to the effects of these cellular modulators and that these agents play a key role in initiation and progression of disease.[7]

Diseased tissue presents in two discrete forms, either as a nodule or as a cord. Each form has distinctive histologic features. Nodules are dense cellular collections of myofibroblasts, representing centers of intense metabolic activity.[11] Dupuytren's cords contain no myofibroblasts but are highly organized collagen structures similar to tendons. Electron-microscopic studies have demonstrated that the myofibroblast in the nodule accounts for active contraction.[11] Nodules produce digital flexion contractures by pulling through cords that have extended past adjacent joints. Myofibroblasts have been identified in dermal and epidermal tissue that is close to, but separate from, discrete nodular foci.[12] Recurrence of disease after surgery may be attributable to residual myofibroblast populations that have migrated into the adjacent dermis and epidermis of the palm. The use of full-thickness skin grafts in advanced cases greatly diminishes the rate of recurrence, perhaps because removal of both nodular tissue and adjacent skin more thoroughly reduces myofibroblast populations.

Anatomy

An understanding of the normal fascial organization of the hand will aid the clinician in unraveling the seemingly chaotic pathoanatomy of Dupuytren's contracture. Normal fascial structures are referred to as bands and ligaments. The two major forms of diseased tissue are referred to as nodules and cords.

The palmar aponeurosis is typically a triangular thin sheet of fascial tissue that becomes more discretely organized distally into "pretendinous bands" that travel toward each digit. Some pretendinous band fibers terminate in skin just distal to the distal palmar crease. However, a portion of the band continues on and immediately bifurcates into two strips that then pass deeper into the palm to wrap around both sides of the metacarpal head, twisting 90 degrees in the process, partially attaching to the metacarpophalangeal (MCP) joint capsule, and blending into the web-space architecture.[13] These deeper twisting extensions of the pretendinous bands are called the spiral bands. The pretendinous bands also give rise to discrete fascial extensions that travel sagittally in the palm and attach to the interosseous muscle fascia. These extensions, called the septa of Legueu and Juvara, create seven compartments, which contain four sets of digital flexor tendons and three groups of neurovascular structures (traveling toward the three ulnarmost digital web spaces)[13] (Fig. 2).

The superficial transverse palmar ligament is primarily a two-dimensional fascial structure in the coronal plane that runs approximately perpendicular to the pretendinous bands across the distal third of the palm. The natatory ligament is also a transversely oriented structure that runs roughly par-

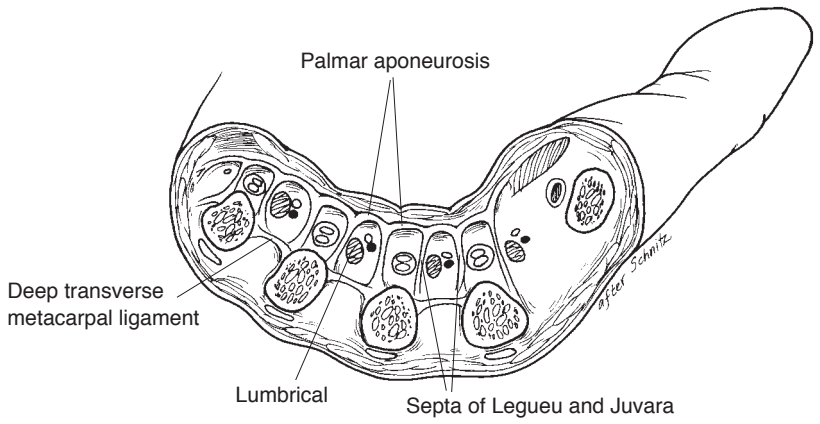

Fig. 2 The seven compartments created by the septa of Legueu and Juvara.

allel to the superficial transverse palmar ligament and travels between the web spaces. However, the natatory ligaments, like the spiral bands, have extensions that travel in three planes and blend into soft-tissue attachments around the MCP joints.[13] The natatory ligaments have some deep fibers that attach to the flexor tendon sheath at the MCP joint; other fibers travel in the coronal plane to blend into the skin and fascia that create the web space.

The web space is therefore a coalescence of fibers from the natatory ligaments, the spiral bands, and the septa of Legueu and Juvara (Fig. 3, A). Distal to the web space, fibers continue to create a fascial structure known as the lateral digital sheet, which courses in the sagittal plane on either side of each finger. As the lateral digital sheet passes distally in the finger, it sends off fibers that attach to the periosteum, the joint capsule, and the tendon sheath. The fibers that pass volar to the neurovascular bundle are referred to as Grayson's ligaments; those passing dorsal to the neurovascular bundle are termed Cleland's ligaments (Fig. 3, B).

As Dupuytren's disease develops, pathologic nodules tend to form in fatty zones, particularly between the MCP and proximal inter-

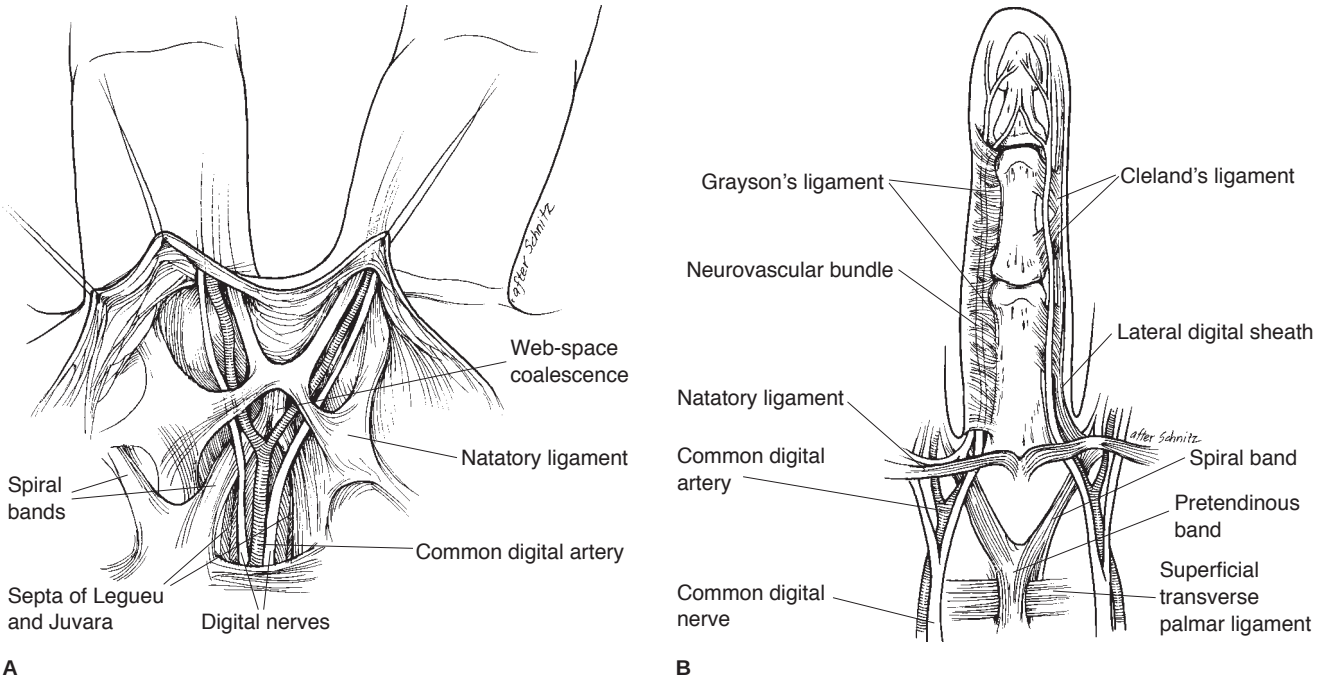

Fig. 3 **A,** The web-space coalescence, consisting of the natatory ligament, the spiral bands, and the septa of Legueu and Juvara. **B,** The fascial structures in the digit and web space, including Grayson's and Cleland's ligaments.

phalangeal (PIP) flexion creases. The nodules contain myofibroblasts and are believed to be responsible for the contractile behavior of Dupuytren's tissue. Controversy exists as to whether nodules give rise to cords or whether nodule formation and cord formation proceed simultaneously and independently. In either case, pathologic cord structures form along the pathways of normal fascial anatomy. For example, pretendinous bands become pretendinous cords, and spiral bands become spiral cords. There tends to emerge a blending of tissue that allows the pretendinous cords, spiral cords, web-space tissue, and the lateral digital sheet to coalesce in a continuous cord. Furthermore, Dupuytren's disease does not present as a simple longitudinally oriented rope of collagen in the coronal plane, but follows the three-dimensional path of the various fascial extensions in the hand. Dupuytren's cords are also usually anchored firmly in the sagittal plane by their attachments to the flexor tendon sheath, joint capsule, interosseous fascia, periosteum, and skin.

Because of the various fascial attachments, the neurovascular bundle in an involved digit or web zone becomes predictably and profoundly intertwined with diseased tissue. For example, the pretendinous band normally is located volar and central with respect to the neurovascular bundle in the palm. As the spiral band proceeds distally, its fibers assume a position dorsal and peripheral to the neurovascular bundle. The next fascial extension, the lateral digital sheet, remains peripheral and dorsal to the nerve until it gives rise to Grayson's ligament, which travels volar to the nerve to connect centrally with the phalangeal periosteum and tendon sheath. When these fascial structures become diseased cords, they blend together as an entire longitudinal unit that wraps completely around the neurovascular bundle as it travels from the palm through the web space and into the digit. This explains why Dupuytren's tissue so predictably encompasses the digital nerves and requires great care in its removal. As the diseased cords contract, the overall encircling pathway becomes more linear (producing a flexion contracture of adjacent joints), while the entrapped neurovascular bundle, which normally travels in a straight line, becomes spiraled around the Dupuytren's cord and is drawn toward the midline of the digit (Fig. 4).

Clinical Features

Demographics

Dupuytren's disease is inherited as an autosomal dominant trait. Factors such as age at presentation and severity of disease may be related to variable penetrance of gene expression. Certain populations show a particularly high prevalence of disease. The greatest concentrations of patients with Dupuytren's disease are located in Scandinavia and Great Britain (especially Ireland and Scotland).[14] Viking heritage seems to be part of the original gene pool, not only because of the high Scandinavian prevalence of the disease, but also because the path of Viking conquests correlates with its world distribution. Viking invasions included campaigns through Iceland to Canada, along the western European coast to the British Isles, and into southeastern Europe. Dupuytren's disease becomes rarer as one travels farther south in Europe. The high prevalence of disease in Australia is almost certainly related to the influx of British and Irish settlers early in its development.[14]

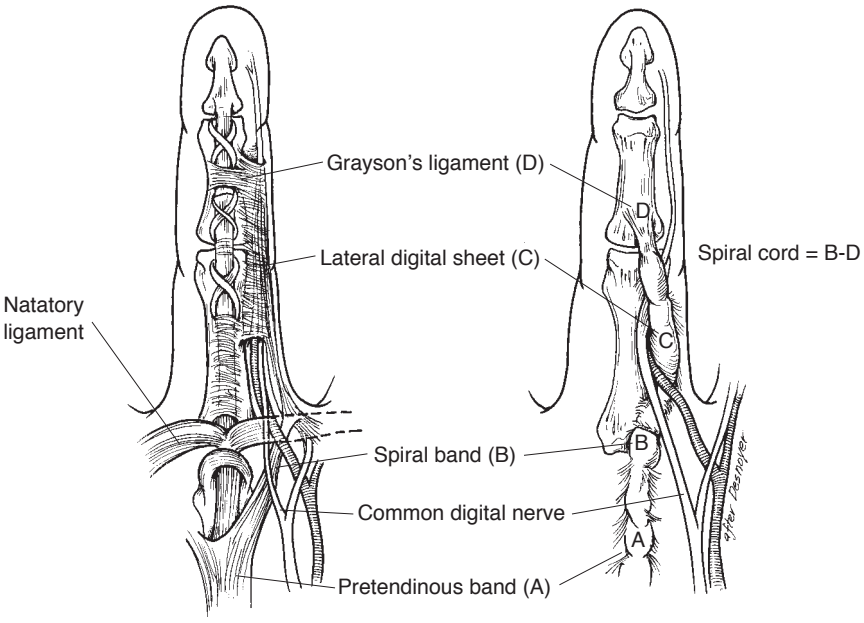

Fig. 4 **Left,** Normal anatomy. **Right,** Formation of a spiral cord from four fascial structures: the pretendinous band, the spiral band, the lateral digital sheet, and Grayson's ligament. The involved digital nerve becomes spiraled around the cord, and the nerve is drawn toward the midline of the digit.

Areas in which the condition is virtually unknown include Greece, the Middle East, and the Orient.

Patient Presentation

Dupuytren's disease is much more common in men than in women (by a ratio of at least 7:1) and commonly presents after age 40.[15] Patients often first seek medical attention after they notice a tender nodule or progressive palmar cord development. In many cases, the process is completely painless, and patients will delay seeking evaluation until joint motion has been seriously compromised. Patients are frequently referred for orthopaedic assessment by their primary-care physician with a presumptive diagnosis of trigger finger or joint stiffness. Although any soft-tissue mass must be carefully assessed as a possible tumor, skin pitting and nodule formation near the distal palmar crease are typical early findings that help confirm the diagnosis of Dupuytren's involvement. Examination of the opposite hand may help confirm the diagnosis, as nodule formation and other early changes may be present bilaterally.

As nodules grow, cords can usually be palpated extending proximally and distally. The ring and small finger are usually the first digits involved, and disease in the palm typically precedes digital involvement. In women, disease expression seems to be more often less severe or atypical; isolated PIP joint involvement or first-web-space contractures may be the main clinical finding. Nodule and cord maturation often follow different courses. Although the nodule forms first and is a major center of biologic activity, the nodules may disappear as the disease progresses. Cord development is the more striking physical finding. As the cord thickens and extends distally, it often has extensions that fan out toward multiple digits.

Progression of disease is unpredictable. Some patients may have minimal findings that are quiescent for years and then demonstrate increased nodule formation and cord extension over a short period. It has been speculated that trauma may be a stimulus for progression in some cases, but there has been no formal scientific evidence supporting overuse trauma as a cause.

"Dupuytren's diathesis" refers to a spectrum of physical findings that is present in patients with particularly strong gene expression for the disease. These patients present several decades earlier in life than those with Dupuytren's diease itself (often in their 20s or 30s) and demonstrate very aggressive cord development with a high incidence of multiple-digit and bilateral hand involvement. Additional physical findings include knuckle pads (also called Garrod's nodes), plantar fibromatosis (Lederhose's disease), and penile fascial involvement (Peyronie's disease). Although these three findings rarely require specific surgical intervention, they can serve to identify patients with Dupuytren's diathesis. Diathesis patients are at a much higher risk for a poor surgical outcome due to higher early recurrence rates, greater risk of technical complications due to complex disease involvement, and longer postoperative rehabilitation.

Disease Recurrence

It is important to remember that Dupuytren's disease is controlled at the genome level; surgical excision of affected tissue does not effect a true cure from a histologic perspective, but rather improves hand function by alleviating contractures. Recurrence of disease is more common in patients who are young at first presentation and in those with Dupuytren's diathesis. Recurrence can be defined as the presence of diseased tissue in a surgically treated field. These lesions may represent new foci of Dupuytren's disease that have, over time, progressed from an adjacent diseased zone that has not been treated surgically. This may be the most common situation in diathesis patients, who demonstrate aggressive and extensive disease; in these patients, diseased tissue from untreated areas is likely to extend into and reinvolve surgically treated territory.

It is also possible that recurrent contracture may be due to the presence of areas of residual disease that were incompletely excised, with myofibroblasts persisting in the skin or dermis. It has been observed that areas treated with full-thickness skin grafts rarely develop recurrent disease, perhaps due to the removal of all tissue layers adjacent to the nodular foci (dermis and epidermis). Whether recurrence is truly due to disease progression or disease persistence, patients should be aware that joint contractures may recur after surgical treatment, especially in young patients and those with a strong diathesis.

Nonoperative Treatment

Reports of treatment of Dupuytren's contracture with a wide variety of nonoperative modalities, including creams, lotions, corticosteroid injections, physical therapy, and splinting, are largely anecdotal. No consistently favorable response has been documented in a large group of patients who have been followed up prospectively. The course of disease progression is notoriously unpredictable, and the literature is replete with isolated reports of spontaneous regres-

sion of contractures, further casting doubt on a cause-and-effect relationship between nonoperative treatments and favorable response.

Perhaps the most valid nonoperative treatment consists of education of both patients and primary-care givers. Frequently, patients with early disease or mild contractures will present with fears or misconceptions regarding the etiology of the nodules and cords in their palms. This situation can be compounded by primary-care physicians who do not recognize the disease process as Dupuytren's contracture. Patients are often reassured when the nature of the condition is explained to them, and they may also be educated as to what signs warrant reevaluation of the affected hand. Education of primary-care physicians will likewise help ensure that referral is recommended before severe contractures become established.

Operative Indications

The "table top" test provides a good guideline for consideration of operative intervention. The test is positive when the patient can no longer place the palm of the affected hand completely flat on a hard surface. This test serves as a simple reference by which patients can check for themselves the progression or significance of a contracture. The test typically correlates with MCP joint contractures that measure more than 30 to 40 degrees. An MCP joint contracture of 40 degrees or more is severe enough to justify operative intervention in most cases. Treatment of other affected digits on the same hand should be considered when their MCP joint contractures are 20 to 30 degrees or more.

While these guidelines are helpful in identifying a threshold for surgical intervention, patient preference also plays a role in treatment choice, especially since Dupuytren's disease is often painless and only slowly progressive. Patients must be educated about potential postoperative complications, the required commitment to postoperative therapy, the degree of risk of recurrence, and the possible need for additional procedures, such as skin grafting. Good communication between patient and surgeon is essential so that appropriate expectations are created.

The PIP joint contracture warrants special consideration. Because complete correction of a PIP joint flexion deformity is difficult to achieve and maintain, operative intervention has generally been recommended when any PIP joint contracture is noted. However, a recent multicenter study[16] demonstrated that while the surgical outcome for severe PIP joint contractures was notable improvement, the outcome for milder contractures (less than 30 degrees) was frequently either no improvement or worsening of the contracture. McFarlane[17] advocates Dupuytren's contracture release only when the PIP joint contracture is 30 degrees or more.

It is important to distinguish a true PIP joint flexion contracture from an apparent one. A spiral cord that originates proximal to the MCP joint and terminates distal to the PIP joint has the potential to produce flexion of both joints. Therefore, MCP joint contractures should be measured with the PIP joint passively extended, and PIP joint contractures should be measured with the MCP joint held in flexion.

Operative Treatment

There are several operative procedures for the correction of Dupuytren's contracture. Most surgeons tend to select one method over another on the basis of their training, experience, and philosophical approach to the disease. The various procedures differ in three ways: management of the palmar fascia, treatment of the volar skin, and design of incisions.

Management of the Palmar Fascia

Methods of treatment for the palmar fascia include radical fasciectomy, selective fasciectomy, segmental fasciectomy, and fasciotomy. With the exception of radical fasciectomy, each method has staunch proponents, and all probably have a role for selected patients.

Once a mainstay of Dupuytren's surgery, radical fasciectomy has largely been abandoned. This approach grew out of the philosophy that resection of all the palmar fascia would prevent disease recurrence and extension. However, recurrence was still reported, and the extensive nature of the procedure led to an unacceptable rate of wound complications.

Selective fasciectomy is the method most commonly used. This procedure involves the resection of all diseased fascia in the palm and finger; adjacent normal fascia is left. Because some diseased fascia (which macroscopically appears normal) will inevitably remain, disease may develop in areas not treated surgically.

Segmental fasciectomy and fasciotomy are limited procedures that achieve a partial or complete correction. Segmental fasciectomy is the removal of one or more segments of diseased fascia through multiple small incisions in the palm and fingers. Alternatively, it can be performed through transverse incisions or longitudinal incisions converted to Z-plasties.

Segmental fasciectomy may also be combined with multiple small full-thickness skin grafts overlying the areas of cord excision, with the intent that these grafts will prevent recurrent disease beneath them. Limited open fasciotomy and percutaneous fasciotomy have been used to obtain modest correction in less severe contractures or partial correction of severe contractures in debilitated or very elderly patients and in patients unable to comply with the postoperative rehabilitation protocol.

Selective fasciectomy is preferable for most patients because this technique provides the best correction with acceptable rehabilitation requirements and complications. For very elderly patients and patients who cannot comply with therapy, fasciotomy is preferred.

Management of the Volar Skin

Three methods of treatment are most commonly used: direct closure after fascial excision, skin excision followed by full-thickness skin grafting, and an open technique in which a portion of the volar skin is left open to close subsequently by wound contraction.

Advantages of direct closure with or without skin-flap rearrangement include primary wound healing, no need for skin grafts, and simple postoperative wound management. Disadvantages of this technique are increased incidence of hematoma formation and skin-flap necrosis and a possible need for skin-flap rearrangements to provide length.

The use of full-thickness skin grafts in the palm and digits has many proponents. Hueston[18] has championed this approach, believing that the palmar skin has a modulating effect on the underlying palmar fascia. This belief is supported by evidence that recurrence is rare beneath areas where palmar skin has been replaced with full-thickness skin grafts. Although control of recurrence is a worthy goal, it must be recognized that use of skin grafts does not control extension of disease beyond the grafted areas and that recurrence is possible at the margins of the graft. Potential disadvantages of skin grafting include complete or partial graft loss; hematoma formation; prolonged immobilization for graft incorporation, possibly resulting in stiffness; altered sensibility over the grafted areas; and altered wear characteristics of the grafted skin compared with normal palmar skin.

An alternative to direct wound closure or skin grafting is the open-wound technique, advocated by McCash[19] in 1964. The technique most frequently involves a transverse incision in the palm at the level of the midpalmar crease combined with additional incisions in the fingers to complete the fasciectomy. At the conclusion of the procedure, the transverse incision, which will be gapped open, is covered with a nonadherent dressing and left open. Once motion is initiated, the wound is simply covered with a dry dressing, which is changed daily. The wound will gradually heal over a period of several weeks. Interestingly, Lubahn et al[20] demonstrated that the open wound does not heal by granulation and epithelialization; rather, the transverse wound contracts to its precontracture length. Other portions of the wound may also be left open as long as their orientation is transverse, not longitudinal.

There are two significant advantages to the use of an open-palm technique. The first is a lower complication rate, specifically with regard to the development of hematoma and wound-edge necrosis. The second is early postoperative patient comfort. Wound infection is rare with the open-palm technique. The major disadvantage to the open-palm technique is the inconvenience to the patient during the 3 to 5 weeks it may take for the wound to close.

Incisions

Fasciotomy and segmental fasciectomy may be performed percutaneously or through transverse incisions, longitudinal incisions converted to Z-plasties, or small curvilinear incisions. The various incision types may be used in combination. Three types of incisions are commonly used to provide wide exposure to the diseased fascia: a longitudinal midline incision with Z-plasty closure, a Brunner zigzag incision, and a zigzag incision with V-Y advancement.

In a finger with a marked contracture, a longitudinal incision in the palm extending into the digit in its midaxial line provides excellent exposure and is simple to perform compared with other incisions. Although the digital nerve is drawn proximally, centrally, and palmarly by a contracted cord, it is rarely drawn completely to the midline of the digit; therefore, a longitudinal midline incision is relatively safe. When the fasciectomy is completed, the longitudinal incision is converted to multiple Z-plasties, optimally placed over the flexion creases, and the flaps are closed. This provides the additional benefit of lengthening the wound. The flaps may be planned but should not be made before completion of the fasciectomy. This allows creation of flaps that are not compromised by the dissection.

The use of Brunner incisions and the use of zigzag incisions with V-Y flaps are similar except that the latter provides some lengthening of the wound. Both types of incisions provide excellent exposure.

For all incision types, flaps must be raised with great care, and flap retraction must be performed gently. It can be helpful to mark the skin first to ensure precise placement of the incision with respect to digital flexion creases and to ensure flap symmetry. To avoid flap necrosis, the base of the flap must be protected from compromise due to dissection or rough retraction. The apex of each flap is often quite thin and tenuous and should also be protected against vigorous manipulation. Nylon retention sutures (5-0 or 6-0) are helpful for retracting flaps; the sutures should be placed completely in the subcuticular layer so that if they inadvertently pull out, the epidermis will not tear. Regardless of incision type, the digital neurovascular bundle will require exposure to adequately protect it as well as to free it from diseased tissue.

A Brunner incision is preferred for most patients. This incision is simple to plan, is reliable in healing and appearance, and usually requires no modification in the patient with mild to moderate involvement. If the contracture is particularly severe in the digit, part of the incision can be left open, and full-thickness skin grafts can be used to fill in the gaps. For patients who have particularly severe involvement in the palm, the palmar portion of the Brunner incision can be substituted for a transverse palmar approach; the incision is then left open and managed with the open-palm technique. Although the open-palm technique certainly has a low wound-complication rate and the wound heals well, some patients prefer not to manage an open wound.

PIP Joint

The PIP joint deserves special consideration. It undoubtedly constitutes the most difficult aspect of surgical treatment of Dupuytren's contracture, especially with regard to outcome. How much correction should be sought and how aggressively joint release should be pursued remain controversial. Clearly, whatever correction can be achieved by resection of diseased fascia should be accomplished. Beyond this, Hueston[18] advocates no further release for a contracture of 40 degrees or less. This is predicated on his belief that hyperextension at the MCP joint can accommodate this degree of contracture and allow the finger to be extended to a palmarly flat position. Furthermore, resection or opening of the flexor sheath may compromise the ability of a full-thickness skin graft to be easily incorporated.

Others have recommended that complete PIP joint extension be obtained in the operating room. However, although obtaining full correction may be appealing in theory, there is evidence to suggest that PIP joint release cannot be easily maintained postoperatively. Rives et al[21] prospectively evaluated 23 PIP joints treated with surgical release for a Dupuytren's contracture of 45 degrees or more. The operative procedure included volar joint capsulotomy, release of the checkrein ligaments, and release of accessory collateral ligaments. Postoperative management consisted of dynamic extension splinting for 6 months. At the 2-year follow-up, only a 44% improvement in PIP joint extension was present (59% in the subgroup of patients who complied with the postoperative splinting program). They noted the same degree of correction for moderately contracted (45 to 60 degrees) and severely contracted (60 to 100 degrees) joints. This experience underscores the difficulty of improving severe PIP joint contractures, even when aggressive surgical release is performed. The most important predictor in gaining improvement was compliance with the postoperative splinting program.

Although it is preferable to attempt release of the PIP joint in cases of severe contracture, it is crucial that the patient be informed preoperatively that maintenance of improvement is difficult and labor-intensive. Near-normal PIP joint motion is a highly unlikely result, and the use of dynamic splinting for a prolonged period postoperatively may be the most important detail in maintaining operative correction. Furthermore, it is essential to recognize that release of the PIP joint adds additional insult to the digit and increases the chance of complications related to dramatic swelling, skin-flap compromise, and prolonged postoperative pain. The exposure required for PIP joint release requires violation of the flexor-tendon pulley system, which adds the potential complication of altering flexor-tendon mechanics.

In summary, careful patient selection and great technical focus are essential when considering PIP joint release in patients with severe contracture. Not every patient is a candidate; the ability to understand potential complications and to participate in a meticulous dynamic splinting program is critical. Exposure of the flexor tendons and release of the PIP joint adds a marked recovery burden that notably increases surgical morbidity. Furthermore, and most important, loss of PIP joint flexion and grip strength can result and ultimately make the digit and hand permanently worse than the preoperative state.

Recurrent Disease and Salvage Procedures

Recurrent contracture severe enough to warrant reoperation constitutes a formidable surgical chal-

lenge. Selective fasciectomy followed by excision and grafting of all of the palmar skin overlying the recurrent contracture is a technique advocated by many. Unlike primary Dupuytren's surgery, the anatomy is not generally predictable, and the risk of complications, including neurovascular injury, is greater. Previous surgery may have resulted in occult injury to a digital artery, and injury to the remaining artery during the course of reoperation may have dire consequences. A preoperative digital Allen test is helpful in identifying digits with impaired circulation.

In some cases of severe recurrent contracture or even severe primary disease, PIP joint fusion or amputation may be a reasonable alternative. Joint fusion usually requires partial contracture release and bone shortening. Candidates for PIP joint fusion include patients with severe flexion contracture (more than 90 degrees), recurrent disease, PIP joint arthritis, and inability or unwillingness to comply with the required postoperative therapy. Indications for amputation include severe recurrent contracture, a PIP joint flexion contracture greater than 90 degrees, a dysvascular digit, a painful or insensate digit, and patient preference.

Postoperative Treatment

The goals of postoperative treatment are to maintain the correction achieved by surgery, to reduce the effects of postoperative edema and scarring, and to restore preoperative flexion and strength. Management involves splinting, active and passive range-of-motion exercises, wound care, scar and edema management, education, and strengthening. The patient's compliance with a home exercise program determines the postoperative course and the time required in a formal therapy program.

Therapy begins 2 to 5 days postoperatively with fabrication of a volar forearm-based splint with the wrist in neutral and the fingers extended as much as possible. The thumb is splinted in extension to minimize web-space contracture. A forearm-based two-thirds splint is recommended instead of a hand-based splint because the former provides a longer lever arm for stability of finger extension.

The frequency and duration of splint usage are dictated by the extent of the surgical procedure and the propensity of the patient to lose motion. Not all patients will require, or even benefit from, splinting. Although extension splinting is commonly emphasized in an effort to maintain the correction achieved surgically, it is important to immediately start active range-of-motion exercises for both flexion and extension. It is possible to inadvertently concentrate on extension posture while allowing the patient to actually lose motion in flexion and subsequently suffer permanent loss of grip strength and terminal digital flexion. The essential ingredient of the postoperative program is early active motion and restoration of grip.

Active range-of-motion exercises are initiated at the patient's first therapy visit. Passive stretching is also performed according to the patient's pain tolerance. Particular attention is directed to the PIP joint because collateral ligament tightness and capsular contraction must be overcome. Joint-blocking exercises are often required to regain distal interphalangeal joint flexion, especially if hyperextension of the joint was present before surgery. Usually by the second postoperative week the patient can be gradually weaned from splinting during the daytime to facilitate functional use of the hand. Nighttime extension splinting should be continued for 3 to 6 months, with periodic checks to ensure proper positioning.

Scar-management techniques, such as massage and use of silicone gel, can be helpful in optimizing the appearance and texture of the scar. Strengthening is initiated after wounds are healed, usually 3 to 4 weeks after primary closure, 4 weeks after skin grafting, and 6 weeks after the open-palm technique.

Complications

The complications of Dupuytren's surgery are numerous and may be related to underestimation of the complexity of the procedure or unfamiliarity with the requirements of postoperative care. The most obvious intraoperative pitfall is inadvertent division of a digital nerve. A thorough understanding of Dupuytren's anatomy is the best defense against this problem, although in patients with severe contracture (especially those with Dupuytren's diathesis), the pathway of the digital nerve can be maddeningly complex. Loupe magnification and great patience are essential to safe unraveling of the nerve.

The preferred technique begins with identification of the neurovascular bundle in the palm, just distal to the superficial transverse palmar ligament. Each nerve is then dissected distally, taking care never to cut any structure without having the nerve and the artery clearly in view and protected. An optical illusion frequently occurs in which the nerve appears to just stop in a mass of diseased fascia; in reality, the nerve has usually traveled deeper into the fascia, turning 90 degrees away from the surgeon's visual perspective and giving the

appearance of a dead end. Another important rule is not to excise any tissue until the digital nerve has been identified on both sides of the excision zone. Once the digital nerves have been completely dissected free of diseased fascia, excision of the Dupuytren's tissue can be quickly and easily accomplished.

Hematoma formation is another common technical problem. Release of the tourniquet before wound closure is advisable so that meticulous hemostasis can be established. Hematoma formation can easily produce wound necrosis because the skin flaps are often thin.

Wound healing difficulties can result from poorly planned incisions or imprecise technique. Care must be taken when designing zigzag incisions so that all flaps have adequate blood supply and webspace skin is not compromised when surgery involves adjacent digits. Dupuytren's disease may directly involve the skin, most obviously in the case of nodules and pitting, and it is easy to inadvertently buttonhole the skin when attempting to elevate a flap. Small defects typically do not result in healing problems; it is preferable to leave them open if any tension is created by attempting to suture the defect.

Vascular compromise of a digit is possible, especially in patients who have undergone previous surgery. In any case of severe contracture, it is wise to carefully examine the vascularity of surgically treated digits when the tourniquet is released. It may be necessary to accept less deformity correction in favor of allowing adequate blood flow to the affected finger.

Compromise may be related to the patient's inability to comply with therapy or to care for the healing incisions. The goals of therapy may need to be suspended temporarily in deference to wound care. It can be helpful to identify those patients less likely to tolerate rigorous therapy or wound care and perhaps limit their surgical intervention to the smaller, less demanding incisions of a segmental fasciotomy.

Reflex sympathetic dystrophy in Dupuytren's patients has been referred to as a "flare" reaction. Its prevalence varies from 1% to 8%, although in one series[22] a rate of 58% was noted in patients who underwent simultaneous carpal tunnel release. It is at least twice as common in female patients with Dupuytren's disease as in male patients. As is the case with any surgical patient, a reflex sympathetic dystrophy event can ruin the results of treatment. Optimal management involves early recognition and immediate treatment with hand therapy and adjunctive modalities, such as nerve blocks and medication when appropriate.

Although not truly a complication of treatment, recurrence definitely spoils the result of surgical intervention. Reported recurrence rates vary from 2% to 63%.[22] Although controversy surrounds the distinction between recurrence of disease and extension of disease, a few principles are clear. Disease recurrence rates are much higher in patients with Dupuytren's diathesis; use of full-thickness skin grafts seems to protect against the return of diseased fascia in grafted areas.

Summary

Dupuytren's contracture is a fibroproliferative disorder that most commonly affects men over age 60 who are of Scandinavian, Irish, or eastern European descent. Operative management is appropriate when metacarpophalangeal or proximal interphalangeal joint contracture exceeds 30 degrees. However, the choice of surgical treatment is dependent to some extent on patient preference and a clear understanding of the possible complications and the considerable postoperative therapy commitment. A volar zigzag Brunner incision in the digit and palm provides reliable exposure and leads to predictable healing in most cases. The mainstay of postoperative hand therapy is early active-flexion range-of-motion exercises to restore grip strength. A nighttime extension splint may be used for several months postoperatively to maintain the correction achieved in the operating room. Early recurrence of disease is most common in individuals with Dupuytren's diathesis; use of full-thickness skin grafts may be helpful in this setting.

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