Dynamic External Fixation in the Treatment of Dupuytren's Contracture

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38.1 Introduction

The management of Dupuytren's disease is particularly difficult when there is significant flexion contracture of the proximal interphalangeal (PIP) joint. Historically, surgeons have attempted palmar and digital fasciotomy or fasciectomy to treat the Dupuytren's. Review of these efforts has documented disappointing results (Rodrigo et al. 1976; Bryan and Ghorbal 1988).

It was not until HK Watson described the "checkrein" ligament release that the operative management of these proximal interphalangeal joints changed significantly (Watson et al. 1979).

The addition of checkrein ligament release to the commonly employed digital fasciectomy is accepted by many surgeons, but checkrein release still dose not address two critical problems found with long-term PIP joint Dupuytren's contractures: (1) Shortening of the neurovascular digital bundles in recurrent cases, (2) Contraction of the soft tissue envelope.

Correction of the soft tissue deficiency by distraction through external fixators has been shown to be a viable option in the treatment of PIP flexion contracture (Messina and Messina 1991, 1993). The Digit Widget™ (Hand Biomechanics Lab Inc, Sacramento, CA) uses dynamic external boney fixation as a means to correct the soft tissue flexion contracture. Additional surgical treatment of the Dupuytren's contracture after soft tissue lengthening may be necessary to achieve a long-lasting result.

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38.2 Treatment of Flexion Contracture at the PIP Joint

When the MCP joint is significantly involved with Dupuytren's contracture, a single stage operative release will often lead to satisfactory function. Unfortunately, disease at the PIP joint is not so easily treated. Few reports in the literature focus on this difficult joint contracture, and controversy still exists over the most appropriate surgical treatment for severe disease. Precise excision of diseased fascia and gentle manipulation can often correct less severe PIP deformities. Persistent or more severe contractures require a logical and systematic evaluation of the causative forces and altered anatomy of the hand (Crowley and Tonkin 1999). This includes evaluation for the need of checkrein ligament release or capsuloligamentous release.

38.2.1 Surgical Anatomy Involved in PIP Flexion Contracture

The PIP joint is a hinge joint, which is stabilized by the geometric configuration of its articular surface, as well as the by the collateral ligaments and the volar plate. It is supported superficially by the thin retinacular ligament of Landsmeer. The more robust deeper layer consists of the collateral ligaments which originate from the proximal phalanx and insert on the volar plate and middle phalanx (Shin and Amadio 2005). Both sides of the volar plate have a bifurcated ligamentous expansion which extends to the volar proximal phalanx. These anchoring structures are known as the "checkrein" ligaments. In the MCP joint, the volar plate contracts with flexion and re-expands with extension. The volar plate anatomy of the PIP joint behaves differently, as it slides proximally and distally with flexion and extension and does not change in configuration. Therefore, any adhesion or limiting force on the PIP volar plate or checkrein ligaments may cause limitations in full extension of this joint (Shin and Amadio 2005).

38.2.2 Checkrein Ligament Release

HK Watson first described the checkrein ligament release for Dupuytren's (Watson et al. 1979). He describes these entities as two thick ligamentous structures that emanate from the volar plate on each side and insert onto the volar sides of the proximal phalangeal periosteum. He surmised that in order to relieve the PIP contracture without violating the joint space, complete relief of the tethering forces of the volar plate was necessary. His 9 year retrospective review included 52 Dupuytren's contractures among the 115 total cases. His operative strategy included exposing the checkrein ligaments through a palmar approach and releasing them at the proximal edge of the volar plate. Following checkrein release, 110 of the 115 joints achieved full extension intraoperatively. Of those remaining, two required collateral ligament release and three required a second checkrein release during the postoperative period (Watson et al. 1979).

38.2.3 Techniques in PIP Flexion Contracture Release

Although many surgeons consider checkrein ligamentous release as the gold standard in operative therapy for difficult PIP flexion contractures, there is certainly no consensus. Commonly, treatment involves a systematic review of the involved Dupuytren's cords, followed by examination of the PIP flexor apparatus, and an additional assessment of the PIP extensor apparatus (Smith 2002). In those patients who do not acquire full extension after cord release, gentle passive manipulation of the PIP into extension with MCP flexion can be undertaken. The idea is to rupture minor periarticular adhesions involved in the contracture. If the flexion deformity persists, the volar plate and checkrein ligaments (capsuloligamentous structures) are assessed and released if thickened. Failure to achieve full extension at this point may be related to shortened accessory collateral ligaments or shortening of the actual tendon sheath, both of which can be released as well (Smith 2002).

Several studies have importantly compared outcomes using these different techniques for the treatment of Dupuytren's contracture involving the proximal interphalangeal joint. Weinzweig et al. retrospectively compared fasciectomy alone with capsuloligamentous release plus fasciectomy for severe PIP Dupuytren's contractures greater than 60° (Weinzweig et al. 1996). Adequate PIP extension was obtained intraoperatively after fasciectomy alone in a subset of 27 PIP joints. In 15 other PIP joints affected by Dupuytren's, persistent contracture of the PIP joint following fasciectomy necessitated further intervention which involved release of the capsuloligamentous structures (including the checkrein ligaments and sometimes the collateral and accessory collateral ligaments). In both of these groups, there was a significant decrease in PIP flexion contracture following surgical intervention. However, they found no difference in the percentage of contracture correction in the capsulotomy group compared with the noncapsulotomy group. In both cases, the degree of correction maintained at surgery was not maintained postoperatively in follow-up.

Beyermann et al. prospectively followed 43 patients with severely contracted PIP joints who underwent fasciectomy combined with postoperative rehabilitation (Beyermann et al. 2004). Eleven of these patients were found to have inadequate release of their flexion contracture (greater than 20° residual flexion) at 6 months. Each of these 11 patients underwent an additional capsuloligamentous release. This additional release resulted in correction of their residual flexion contractures in every case.

Ultimately, a true balance between flexion and extension is necessary to truly correct a difficult flexion deformity in the proximal interphalangeal joint. One must be cognizant of the opposing extensor forces and realize that the extensor apparatus may be incompetent when treating a flexion contracture. After treatment and once the PIP joint can be passively extended, the central slip tenodesis test plays an important role in the complete workup and treatment of PIP Dupuytren's contractures. By flexing the wrist and MCP, the PIP should become fully extended. Otherwise, the central slip may be attenuated due to the flexion contracture. Full extension will never be able to take place without competence of the extensor apparatus. Methods to correct this problem in less severe PIP contractures have included treatment by extension splinting/fixation to heal the extensor apparatus (Smith 2002).

38.3 Soft Tissue Shortening in Dupuytren's

The checkrein ligamentous release plays an important role in the treatment of the severely contracted PIP joint from Dupuytren's. But this and other surgical steps do not address the important problem of soft tissue shortening involved with severe Dupuytren's disease. The soft tissue envelope around the joint is normally redundant and flexible. This laxity and compliance allows for full flexion and extension without creating undue tension on the skin and underlying tissues. During the evolution of a flexion joint contracture, this dynamic covering loses its compliance and shortens. Not only is the skin and underlying soft tissue affected, but the neurovascular bundles can become extremely shortened and fibrotic as well. In the case where the digit extends beyond the ability of the vessels to expand, the vessels may spasm and thrombose. Digital ischemia is an unfortunate result of vigorous passive PIP joint extension in the presence of shortened neurovascular bundles.

In the past, Dupuytren's disease was considered to be end stage at the point in which these neurovascular bundles are fibrosed and shortened (Smith 2002). Surgical correction was considered prohibitive, and amputation or digit shortening arthrodesis were considered salvage options. The soft tissue envelope shortening and resultant problems with wound closure necessitates the use of skin grafting and flap coverage. Each of these techniques sacrifices a donor area, and they may not provide a functional or cosmetically appealing result. Thus, a method of correcting the flexion joint contracture while also stimulating the growth and expansion of the palmar soft tissues would be ideal.

38.4 Soft Tissue Distraction for PIP Joint Flexion Contractures

Traditionally, splints have been used as the extensor force to correct soft tissue deficiencies in joint contractures. The problem with serial splinting and casting is that the skin and soft tissues limit the amount of force that can be applied. Undue pressure can cause pain as well as skin and soft tissue breakdown. Alternatively, by delivering this extensor force to the boney skeleton, much more effective torque can be delivered across a joint without jeopardizing the skin and soft tissues.

38.4.1 Historical Background, Distraction Osteogenesis

Distraction osteogenesis has become an accepted technique for bone lengthening. Ilizarov's work popularized this method for use in difficult cases which require a long bone graft to correct shortening (Ilizarov 1990). Gradual distraction after corticotomy results in long bone formation and bone lengthening. Importantly, as the bone lengthens, the soft tissue structures including nerves and vessels also expand around this construct. Without growth and expansion of the soft tissues, boney distraction could not be successful. This basic principle has fueled the evolution of other methods which use dynamic external fixation for conditions with shortened soft tissue – including joint contractures.

Other upper extremity conditions which require soft tissue lengthening have been successfully treated using distraction. Congenital deficiencies of the radius, involving radius aplasia or hypoplasia, result in a shortened forearm and radially deviated hand (Smith 2002). Centralization of the hand at the distal end of the ulna is commonly used to correct this abnormality. One problem with this correction involves a relative deficiency of radial skin and radial soft tissues that must be dealt with at the time of centralization. Smith and Greene have reported their experience with use of a dynamic external fixator for soft tissue distraction in congenitally deficient forearms (Smith and Greene 1995). In five (four radial deficient, one ulnar deficient) limbs, an Orthofix external distractor (EBI Medical Systems, Inc., Parsipanny, NJ) was placed. For the cases of radially deficient limbs, soft tissue distraction was continued until the hand could be passively centralized without radial deviation This was successfully carried out with a 1 mm/day distraction rate for an average of 1.1 cm total distraction. After formal radial centralization, the limbs remained in proper alignment at a mean of 14 months later.

38.4.2 Biologic Basis of Distraction

In vitro and biochemical analysis of soft tissue distraction demonstrates many interesting results. It is the cross-linking of collagen fibers that delivers the innate soft tissue strength and resistance to expansion. Bailey et al. found increased enzymatic activity (metalloproteinases, collagenase, gelatinase, cathespins) during soft tissue distraction, which led to depolymerization and cross-link breakdown of collagen (Bailey et al. 1994). They believed that the increased tension delivered by the mechanical stressor on the fibrous tissue initiated enzymatic degradation of collagen, thus weakening the fibers and increasing new collagen synthesis. Tarlton et al. confirmed these in vitro results with Dupuytren's tissue and demonstrated that there is a clear correlation between the force applied to the tissue and release of matrix metalloproteinases (Tarlton et al. 1998). The degraded collagen thus loses its strength due to enzymatic breakdown from mechanical stress and not from other sources such as an inflammatory-mediated etiology.

The microvasculature is also affected in Dupuytren's tissue when external mechanical stress is applied. Brandes et al. demonstrated that dynamic external forces likely change the microfilaments, connections to adherins junctions, and other contacts within endothelial cells (Brandes et al. 1996). The contractile component of the endothelial cell cytoskeleton is altered, which likely helps conform to the external forces applied.

38.4.3 Dynamic External Fixators

The use of dynamic skeletal fixation devices to improve flexion contractures of the PIP joint is not a novel technique. The TEC (Continuous Extension Technique) by A. Messina is perhaps the most studied in the literature.

The TEC device was first reported in the literature in 1991, but in 1993, Messina and Messina reported their expanded results over 5 years in the treatment of patients with Dupuytren's disease (Messina and Messina 1991, 1993). They treated some patients using the device only and others using the device as a preoperative preparation, followed by fasciectomy. The latter group demonstrated fewer flexion contracture recurrences. They concluded that this method of dynamic external fixation offered an alternative to finger amputation or plastic surgical correction of skin and tissue loss in those patients with increased risk for ischemia, necrosis, loss of vascularity, and bad function.

Other soft tissue distractors have been reported to correct PIP joint contracture due to Dupuytren's. These devices include the Pipster (Hodgkinson 1994), Multiplaner Distracter (Kasabian et al. 1998), and S Quattro (Beard and Trail 1996; Rajesh et al. 2000) among others.

Since the evolution and acceptance of soft tissue distraction, there have been various protocols and methods of using the dynamic external fixator. Houshian and Chikkamuniyappa attempted to determine the optimum rate, amount of daily distraction, and the optimum duration of use with a dynamic external fixator (Houshian and Chikkamuniyappa 2007). Two groups were compared using a distraction rate of 0.5 mm/day vs. 1.0 mm/day. Although their study was underpowered, they found no statistically significant differences in the two rates of distraction. This follows common protocols of boney lengthening by distraction in orthognathic surgery that uses rates between 0.5 and 1.0 mm/day.

38.5 Digit Widget™ as a Dynamic External Fixator in Treatment of Dupuytren's

The Digit Widget™ (Hand Biomechanics Lab, Sacramento, CA) is one such device that was particularly developed as a dynamic external fixator for severe PIP flexion contractures. This device, introduced by Dr. John Agee in 2001, has been used with favorable results in the treatment of Dupuytren's PIP contracture. The Digit Widget™ performs soft tissue distraction with accompanying growth of the soft tissue envelope and neurovascular tissues. The external force is transmitted as torque directly to the boney skeleton, thus avoiding the problems associated with splinting and casting which may cause undue soft tissue pressure. An additional benefit with treatment is that full flexion of the PIP may take place with the device in place, thereby encouraging therapy and use of the hand during treatment. The overall treatment plan must include any other steps which may be needed to correct the cause of the flexion deformity (Agee 2010).

38.5.1 Digit Widget™ Installation and Treatment

The Digit Widget™ is installed similar to other external fixators with pins anchored into the middle phalanx bone just distal to the contracted PIP joint (Fig. 38.1). The connector device is then assembled to the anchoring pins and attached to a removable hand cuff (Fig. 38.2). Elastic bands create torque and dictate the extensile force transmitted across the joint. The bands and cuff can be removed for PIP flexion therapy and activity.

Fig. 38.1 Installation of Digit Widget™: percutaneous pin insertion distal to PIP in dorsal middle phalanx of small finger

Fig. 38.2 Digit Widget™ external fixator in place with removable hand cuff

38.5.2 Clinical Experience with Digit Widget™

In practice, the Digit Widget™ is used as an adjunct to operative flexion contracture release in those patients felt severe enough to warrant invasive treatment. For these cases, the Digit Widget™ can be applied to lengthen the soft tissue envelope and neurovascular structures in preparation for definitive operative treatment of the PIP

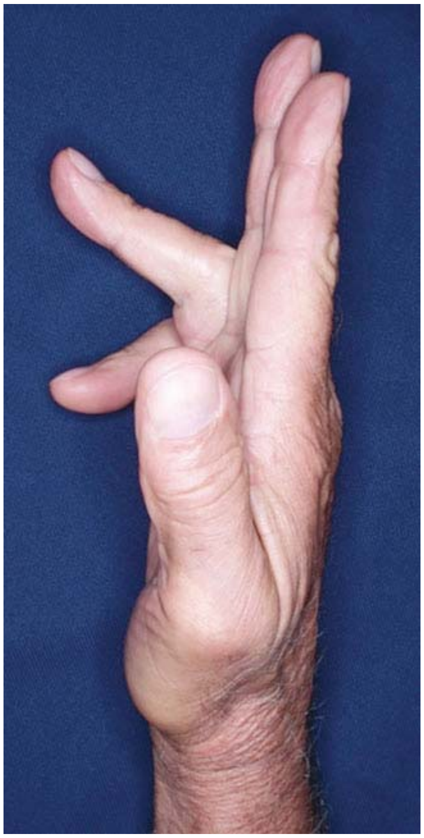

Fig. 38.3 Preoperative view 90° PIP flexion contracture of right small finger due to Dupuytren's before application of Digit Widget™

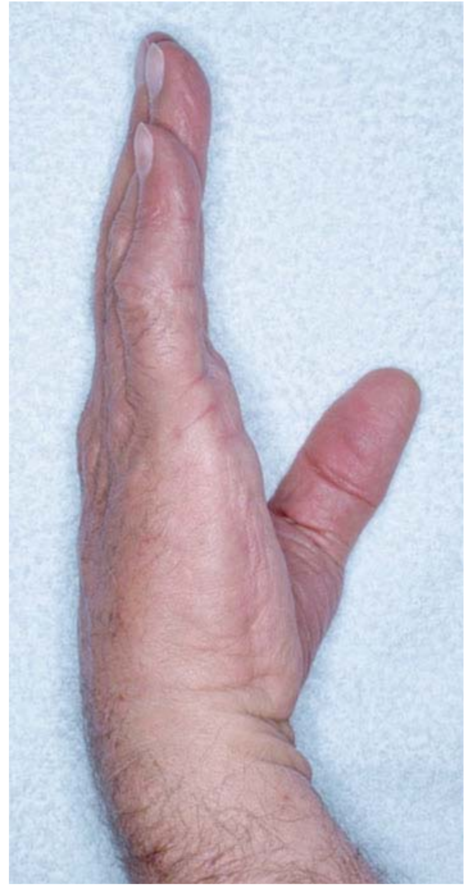

Fig. 38.4 Same patient, 5 months after placement of Digit Widget™. After 6 weeks of soft tissue distraction and hand therapy, the external fixator was removed and the MCP and PIP contractures were surgically released from the right small finger

contracture (often involving exploration of the volar plate and checkrein ligament release) (Figs. 38.3 and 38.4). In some patients, the Digit Widget™ has so completely reversed the contracture that no further intervention has been necessary. This particular strategy may augment operative release of checkrein ligaments in very severe flexion contractures of the PIP joint. Additionally, it seems that the Digit Widget™ may be useful in treating reoperative PIP flexion contractures.

The author's (Smith AA) own experience with the Digit Widget™ has shown promising results. In a series of 30 patients (37 digits), a comparison is made between those who underwent PIP joint checkrein ligament release (CRLR) following fasciectomy versus those who had preoperative placement of the Digit Widget™ (Craft et al. 2011). Of the 20 digits treated with CRLR, a mean of 27.7° of PIP joint extension improvement was observed. But included in this group, 3 of these digits actually developed an increase in flexion contracture, with an average of 16° (2–48°). Comparatively, the average improvement of PIP joint extension in the Digit Widget™ cohort was 54.7°. None of the digits in the Digit Widget™ group experienced worsening contracture, and in fact 3 digits improved to full extension without requiring surgical release. Additionally, the Digit Widget™ group seemed to fare better in those digits with severe PIP joint contractures (61° or greater). Of the 8 CRLR digits with severe preoperative contracture, 1 patient developed worsening contracture of 3° and overall improvement was a mean of 35.3°. In contrast, none of the 10 Digit Widget™-treated joints with severe contractures developed worsening contracture, and mean improvement was 57.3° (Craft et al. 2011).

38.6 Discussion

Dupuytren's disease can be difficult to treat regardless of the location of joint contracture. Proximal interphalangeal joint flexion contractures are particularly problematic. The involvement of fibrous cords, the volar plate, the checkrein ligaments, and incompetent extensor structures make operative treatment difficult. In addition, the soft tissue shortening and accompanying deficiency in neurovascular structures must be addressed as well. Soft tissue distraction using a dynamic external fixator, such as the Digit Widget™, provides an additional tool to combat these difficult PIP contractures. The principles of distraction are sound, and the sparse data on its efficacy in treating the PIP flexion contracture appears promising. Certainly future randomized prospective trials comparing distraction and conventional treatment would be helpful in determining the importance of dynamic external fixation. Ultimately, the treating physician must find the appropriate balance between extension and flexion forces to treat the disease. Dynamic external fixation should be viewed as an important option in the treatment of Dupuytren's disease at the PIP joint.

38.7 Conclusions

- Flexion contractures of the PIP joint in Dupuytren's disease are difficult to treat.
- The surgical treatment of PIP contracture continues to evolve and no consensus exists.
- Soft tissue shortening involved with Dupuytren's contracture presents a significant risk for ischemia and tissue loss after surgical correction.
- Dynamic external fixation is a method of soft tissue distraction that causes the tissues to "grow."
- The Digit Widget™ uses the idea of dynamic external fixation to correct difficult to treat PIP flexion contractures due to Dupuytren's disease.

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