We use the word stiff (which means difficult to bend; rigid) to describe hand joints that lack motion and provide resistance to movement. The soft tissue structures in the hand do not harden like concrete to become inherently “stiff,” but rather undergo a change in their physical properties preventing them from moving relative to one another.

**Injury/Stress Deprivation**

There are two ways joints become stiff. First, the healing process following trauma develops new collagen which is relatively disorganized and thus resistant to movement. Second, uninjured, immobilized joints undergo stress deprivation, triggering excessive collagen cross-linking. For example, the tissue layers in the dorsal apparatus of the normal finger glide laterally and distally during finger flexion and extension while the PIP joint capsular structures also move relative to one another (Figure 1). Following trauma to the PIP joint or lack of PIP joint movement, the absence of essential stress creates a lack of differential glide of these structures which is perceived as stiffness. The application of controlled stress (motion) across stiff joints both aligns new collagen fibers to decrease resistance and maintains lubrication within the collagen cell matrix to prevent abnormal cross-linking.

Therapists often apply a mobilization orthosis to a stiff joint intermittently with the intention of applying “low-load prolonged stress” to alter tissue, but the intermittent application defies the definition of “prolonged.” What is needed is deformation of the soft tissue by frequent repeated stress application instead of the short-lived visco-elastic response (stretched collagen returns to original length and shape). It is the visco-elastic behavior of human tissue that dooms passive stretching to limited use in managing joint stiffness because change results only from prolonged, repeated appropriate stress application.

**Stiff Joints Create Brain Changes**

During joint immobilization and/or limited joint motion, the brain changes the motor representation in response to the altered movement. Multiple studies have shown that motor areas that are used enlarge, and those unused lose cortical representation. An example is a patient who has sustained a distal radius fracture.

![Figure 1. The various tissue layers of the dorsal apparatus of the finger move relative to one another to allow interphalangeal joint flexion.](Image)

![Figure 2. Following immobilization for a distal radius fracture, this patient initiates finger flexion with the metacarpophalangeal joints rather than the interphalangeal joints.](Image)
When a joint has a hard-end feel, the intuitive response is to push the stiff joint to apply enough stress to recreate joint movement; traditional treatment assumes PROM is necessary to regain active range of motion.

**Determining Appropriate Treatment Approach**

Therapists often describe joint motion as having a soft-end feel or a hard-end feel. Joints with a soft-end feel describe collagen with minimal cross-linking and the presence of edema (the softness at end range). A joint with a hard-end feel identifies tissue with significant collagen cross-linking, preventing differential tissue glide and providing a defined end point to passive motion.

A soft-end feel joint is responsive to gentle stress at this stage of early collagen cross-linking. Intermittent stress is usually effective if followed by active motion. Passive range of motion (PROM) is appropriate, but must be defined as a gentle, slow, sustained stretch that never results in pain or increased inflammatory response. Balanced active motion can easily be restored because re-patterning of the motor cortex has not yet occurred; only encouragement is needed to change the tissue.

When a joint has a hard-end feel, the intuitive response is to push the stiff joint to apply enough stress to recreate joint movement; traditional treatment assumes PROM is necessary to regain active range of motion. Ironically, the stiffer the joint, the less passive range of motion is effective because it is short-lived and intermittent. Several studies suggest that short-term passive range of motion may initially have a positive effect, but proof of a long-term positive effect is absent and there is suggestion of a negative response to intermittent PROM in the presence of joint stiffness.10-12

During wrist immobilization, finger flexion may be initiated with metacarpophalangeal (MP) joint flexion rather than interphalangeal joint flexion. When the wrist immobilization is removed, the motor cortex has re-defined the beginning of finger flexion as starting with MP joint flexion (Figure 2). To alter this brain change resulting from muscle imbalance, the muscles unemployed while the wrist was immobilized must be activated repeatedly over time to reestablish their proportional cortical representation. This cannot be accomplished with passive motion.

**Figure 1.** The various tissue layers of the dorsal apparatus of the finger move relative to one another to allow interphalangeal joint flexion.

**Figure 2.** Following immobilization for a distal radius fracture, this patient initiates finger flexion with the metacarpophalangeal joints rather than the interphalangeal joints.

**Figure 3.** A dynamic PIP joint extension orthosis imposes immobilization and constriction while passively extending the PIP joint.

**Figure 4.** Following removal of a dynamic PIP extension orthosis, the patient continues to hyperextend the MP joint instead of the PIP joint.
There is no cortical input to change the pattern of active motion when wearing an orthosis. If active motion of the stiff joint is not part of the treatment, how can the patient re-learn the desired motion? An example is traditional treatment of a stiff proximal interphalangeal (PIP) joint. An orthosis provides a passive force for increased passive PIP joint extension, but also imposes periods of relative immobilization and constriction (Figure 3). Between sessions of orthotic use, the patient reverts to hyperflexion and/or hyperextension of the less stiff MP joint instead of full movement of the stiffer PIP joint (Figure 4). This explains why we are so frequently frustrated with the inability to actively maintain PIP joint extension gained passively.

**Active Redirection**

I have created a term called *active redirection*, describing the simple concept of blocking normal joints so stiff joints receive the muscle power needed to move them. Clinical observation proves that PIP joint contractures of the ring and little fingers resulting from ulnar palsy claw deformity regain full PIP joint extension when the MP joint is blocked from full extension. The difference between blocking exercises and active redirection is duration.

Active redirection is accomplished during waking hours when movement is volitional and replaces any and all passive range of motion. This can be applied as a blocking orthosis worn during waking hours (Figure 5.1-5.3) or, if the stiffness is severe, as a non-removable cast worn full time until rebalance of motion is achieved in the stiff joint(s)\(^{13,14}\) (Figure 6). Passive range of motion is not necessary to mobilize stiff joints if cyclical active motion is repeated frequently and the patient cannot revert to the previous imbalanced pattern of motion. Active redirection when MP joint hypertension is blocked and the stiff PIP joint moves actively into full extension throughout the day simultaneously accomplishes differential glide of tissues.

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**Figure 5.1-5.3.** A small custom-molded orthosis blocks MP joint extension of the little finger to drive the extension force to the stiffer PIP joint.

**Figure 6.** A non-removable cast focuses all active flexion and extension to the finger interphalangeal joints until motion in these joints is regained.
planes, reduction of digital edema and motor cortex remapping.

The Future
In the future, I envision new tools to assist us in mobilizing stiff joints. Scientists have recently developed wearable, stretchable, multifunctional silver nanowire sensors that can be applied directly over joints to provide feedback about the pattern of active motion.15 Perhaps our focus will move toward prevention. Recent studies demonstrate that observation of hand action shows more cortical activity than viewing a landscape or imagining one's hand moving.16 Vibration applied to immobilized hands shows preserved sensorimotor networks in comparison to immobilized hands without vibration.17

Regardless of the new tools we may use, I hope we will shift our focus from passive range of motion to redirected active motion, providing the ideal dosage of both mechanical and cortical stress.

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References