Basic science & injury of tendon & ligament

서울아산병원 정형외과

빈 성 일

Basic science of tendon & ligament

Basic anatomy

1. Composition of tendon & ligament

—Histologically, dense, regularly oriented, connective tissue
: containing parallel rows of fibroblasts within parallel bundles of collagen fibers

—The fibroblasts are responsible for secreting the extracellular matrix

—Ultrastructure of ligament & tendon
: similar, but fibers of ligament are more variable & have a higher elastin content.

① fibroblasts

② Water

③ Collagen fibers
: run in the longitudinal direction, parallel to the axis of loading
: primarily type I (70% dry weight of ligament, 85% dry weight of tendon)
: small amount of type III
: trace amounts of types V, X, XII, and XIV

④ Non-collagenous protein : elastin, fibrillar protein, proteoglycans

* Crimp
: undulating pattern of the collagen (histologically visible phenomenon)
: related to a certain degree of elasticity within the ligament

2. The insertions of tendons and ligaments

: The insertions of tendons and ligaments into bone are functionally adapted to dissipate forces through the transition from soft tissues to bone

* Classification of insertion

: Direct or indirect

① Direct insertions

: consist of four morphologic zones

: Tendon, fibrocartilage, mineralized fibrocartilage, and bone

② Indirect insertions

: Superficial layer, which connects directly with the periosteum

: Deeper layers that anchor to the bone via Sharpey's fibers

Mechanical properties of the ligament substance

: When the elongation limits of a ligament are exceeded a characteristic failure pattern occur

: Ligaments have a typical stress-strain curve

1. Stress-strain curve

-divided into four major components that reflect the physical response of the ligament

-stress : defined as the load per unit cross-sectional area of a ligament

-strain : defined as the deformation per unit length of a ligament

① First region

: nonlinear toe region

: initial area, represents the straightening of the collagen crimp

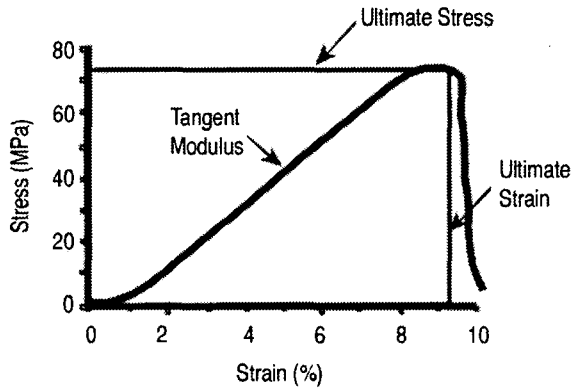
② Second region

: linear functional region

: stress is linearly proportional to the strain

③ Third region
: early failure region, microscopic disruption
: ligament still has a normal gross appearance
: still able to resist some tensile force

④ Fourth region
: failure region, complete ligament failure
: ligament is not able to resist any tensile loading



* Failure mode of ligaments appears to depend on several factors,
: axis of loading, strain rate, age, and activity level.

Physiology of ligament healing

Phase I : inflammation
① damage of capillaries within the ligament and adjacent tissues
② hematoma fills the space created by the displacement & retraction of ligament ends
③ in response to the injury and their exposure to the fibrin of the blood clot,
: most cells release potent vasodilators
: such as histamaine, serotonin, bradykinins, and prostaglandins
→ help initiate the healing process in the gap between the injured ligament ends
④ occur during the first 72 hours after injury

⑤ histology
: inflammatory cells and erythrocyte are seen fill the injured area
: macrophages begins the phagocytosis of necrotic tissue and cellular debris
: capillary endothelial proliferation into the wound
: fibroblastic proliferation begins.
→ produce an extracellular "scar" matrix of proteoglycan and collagen.
: most of the newly synthesized collagen in ligament scar : type III
→ responsible for early stabilization of the extracellular collagen meshwork
: small portion of type I collagen
→ more important to long-term matrix properties

Phase II : matrix and cellular proliferation
① occurs over the next 6 weeks
② organization of the fibrin clot and is characterized by cellular and matrix proliferation.
③ the scar is very cellular and contains macrophages, mast cells, and fibroblasts.
④ the gap between the torn ligament ends
: filled with a friable, vascular, granulation tissue, and
⑤ the fibroblast is the predominant cell type.
⑥ active collagen synthesis occurs
: in both the proliferation scar and the adjacent normal-appearing tissue.
: but collagen concentration remains low
→ because of the less dense, woven organization of the collagen framework.
⑦ type I collagen is the predominant matrix component during this phase.

Phase III : remodeling
① relative decrease in the cellularity and vascularity of the reparative scar
② increase in the collagen density of the scar
③ ligament scar : more organized and packed collagen arrangement
④ biochemically, active matrix synthesis decreases

⑤ biochemical profile of the extracellular matrix moves toward that of normal ligament

Phase IV : Maturation

① the ligament scar gradually matures over the next several months

② this phase of healing is extremely variable

: probably requires 12 months or more to be complete

Injuries of tendon & ligament of the knee

Classification of ligament injuries

1. Sprain

① First degree sprain

: tear of a minimum number of fibers (microtears or less than one third) of a ligament

: with localized tenderness and no instability or laxity

② Second degree sprain

: tear of more ligamentous fibers (one to two thirds)

: with more loss of function and more effusion but no laxity or noticeable instability.

③ Third degree sprain

: more disruption of fibers (greater than two thirds) and demonstrable laxity

: further subdivided into three categories

2. Grading of third-degree sprains (Instability)

① Grade 1 (mild) rupture : 〈 0.5 cm opening of joint space or translation

② Grade 2 (moderate) rupture : 0.5~1 cm

③ Grade 3 (severe) rupture : 〉 1 cm