≪심포지움 III (Rotator Cuff) 16:40 ~ 16:50≫

Pathophysiology and Conservative Treatment of Rotator Cuff Disease

전 재 명
울산의대 서울 중앙병원 정형외과학교실

Rotator Cuff Disease

Most common cause of dysfunction of the shoulder in adults
Bursitis - Tendonopathy
Partial or Full thickness tear
Arthropathy

Rotator Cuff Disease

Smith, 1834; Autopsy of Rotator Cuff Tear
Codman, 1911; First Repair of Cuff Tear
Neer, 1972; Anterior Acromioplasty

ANATOMY

Rotator Cuff Tendon

Unique

- Differs morphologically from a typical tendon
- Interdigitating confluence of collagen bundles from muscles
- Form a hood or aponeurosis over the humeral head

Primary Function of Rotator Cuff

Humeral head depressor
Dynamic stabilizer of the glenohumeral joint
Creating a fulcrum
Rotation of the humeral head

Four Parts of Tendon Insertion

1. Nonmineralized fibrocartilage
2. Blue line
3. Mineralized fibrocartilage
4. Bone

Structure

One Continuous Band
Five Layers of Insertion

1. Superficial layer of coracohumeral ligament
2. Primary portion of the cuff tendons
3. Thick tendinous structure with tendon fascicles (smaller and less uniformly oriented)
4. Deep extension of the coracohumeral ligament (perpendicular fiber to the cuff tendon)
5. True capsular layer

Fiber Orientation

Flat ribbonlike bundles of fibers
Cross at an angle of about 45′
Distinct layers within capsular complex
Significant shear stress
  Play a role in cuff tears
    (Gohlke F, Daum P, Eulert J)

Subacromial-Subdeltoid Bursa

One or more layers of synovial cells
Subacromial bursa
  overlies the rotator cuff tendons
  continuous with the subdeltoid bursa
A primary bursitis without tendinopathy; Rare

Coracoacromial arch

Acromion
Coracoacromial ligament
Coracoid process
  Rigid, Unyielding structure
  Humeral head, Rotator cuffs, Bursa
    Must glide under the CA arch

Role of CA arch

Important passive stabilizer
  against superior humeral subluxation
May be the last restraint

Subacromial contact area and pressure studies

Visual assessment, Dye, Pressure-sensitive film, Capacitive sensors
Peak pressure ; at the anterolateral border of the acromion

Subacromial Pressure

Supraspinatus force removed
  small, not significant decrease
Lack of subscapularis, infraspinatus, and teres minor
  significant increase
Stimulation of the deltoid muscle alone
  a moderate increase
Upward impingimg force of the deltoid
  counteracted by subscapularis, infraspinatus, teres minor, supraspinatus muscle; synergy with the deltoid.

Acromion

Two or three center of ossification
Fuse by age 22 years
Failure - Os acromiale - 1.4% with 62% being bilateral

Coracoacromial Ligament

Triangular; Broad at the coracoid side

From lateral aspect of the coracoid process
To the anteroinferior aspect of the acromion

Three Types of Coracoacromial Ligament
1). Quadrangular
2). Y-shaped, consisting of both lateral and medial bands
3). One broad band

Insertions of Coracoacromial Ligament
More superficial part
Inserts into the anteromedial aspect
Deeper part
Inserts into the undersurface of the acromion.

Characteristics of lateral band
Most likely to impinge on the rotator cuff
a smaller more variable medial band
Length; significantly shorter
Cross-sectional area; significantly larger with rotator cuff tears
Material properties
elastic modulus ; lower with rotator cuff tears

CA Ligament Resection
Increased subluxation
Loss of buffering contact
Loss of "tethering"
Upward bending of the acromion

Fate after Resection of CA Ligament
Regeneration
Reattached to the anterior edge of the acromion
Constituting a New Coracoacromial Arch
(Levy O, Copeland SA, 1998, ICSS)

<u>BIOMECHANICS</u>
Mechanical property of Supraspiantus Tendon (Itoi)
Posterior portion; significantly thinner
Anterior portion; mechanically strongest
seems to perform the main functional role

Articular versus Bursal side (Nakajima et al)
Joint side SS tendon; Weaker in tension than the bursal side
Joint side; More susceptible to mechanical failure in tension
Sharkey and Marder
Concurrent application of forces to the supraspiantus Infraspiantus-teres minor and subscapularis
significantly reduced the required deltoid force
by an average of 26% and 36%, respectively.
Thompson
Paralysis of the supraspinatus

required to initiate abduction
significantly increase in the deltoid force
Tears of a more global nature
Inability to elevate beyond 25 degrees of glenohumeral abduction despite a threefold increase in deltoid force
Intact "transverse force" couple
Not significantly affected glenohumeral joint motion

Supraspinatus tears
May increase the deltoid force needed to lift the arm
But don't alter kinematics

Force Couple (Burkhart)
A balance of forces anterior and posteriorly
might preserve stability
Thick free edge of the cuff tear
might transmit stresses as a suspension bridge

Spacer Effect (Flatow)
Omitting the force to the supraspiantus tendon
Leaving that tendon intact
Slight superior subluxation
Additional supraspinatus tendon defect
Significantly increased superior subluxation

BIOLOGY

Tendon
Water ; 55% of wet weight
Type I Collagen ; 85% of dry weight
other ; other collagen, proteoglycans, cells

Tendon Proper
Bundles of Collagen; Mainly Type I Fibers
Endotenon ; mainly Collagen Type III
Increased with tendon degeneration, age, rotator cuff tears
No Collagen Type II in Normal Tendon Proper
Zone of Attachment; Fibrocartilage, Collagen Type II
Others ; type V, XII, XIV

Load a tendon
Affect collagen fibril number, thickness, and alignment
Exercise
Larger fibrils
Broad distribution of fibril diameters
Increased fibril packing density

Stress deprivation on tendon
Deleterious effects
Immobilization
Alteration in collagen mass, cross linking, turnover

Proteoglycans

<1% dry weight in the tendon
predomiant proteoglycan ; decorin
others ; biglycan, fibromodulin, lumican, aggrecan, vesican

Fibrocartilage

Round cells
Significant amount of the large proteoglycan aggrecan
Assumption; resist pressure
Insertion into bone
- greatest amount
  - insert into bone at the greater angle severe angular movement during normal motion

Mechanisms of Fibroblast Response

Stress-generated potentials
Mechanosensitive ion channels
Membrane-bound stretch receptors

Normal supraspinatus tendon

Glycosaminoglycan composition of tendon fibrocartilage
- An adaptation to mechanical forces (Riley)

Layers of proteoglycan-rich material between collagen bundle

Separate individual fiber bundles
Minimize shear stress as they move relative to one another
- Refior ; results of degenerative changes

Fibroblast of Rotator Cuff Tendon

Unique?

A shift in proteoglycan composition

Response to compression
Impairs the tendon's ability to withstand tensile forces ?

Bursal surface

Increased transcript levels of aggrecan and biglycan
- Relative to cells on the articualr surface

Aggrecan transcript level

Significantly increased in the supraspinatus and infraspinatus
- when compared with the subscapularis

<u>PATHOGENESIS</u>

Causes of Rotator cuff disease

Extrinsic
- macrotrauma
- repetitive microtrauma
- primary subacromial impingement

secondary impingement
internal impingement

Intrinsic

hypovascularity
primary age related degeneration

<u>Extrinsic causes</u>

Mechanical impingement

Meyer; mechanical attrition under the acromion, 1931
Neer, 1972

differences in the size and shape
of the structures of the supraspinatus outlet

Neer ; 95% tears of the rotator cuff - initiated by impingement

Three stages

Principal causative factor

Abnomalities

shape and slope of the acromion
CA ligament (Neer)

<u>Bone</u>

Acromial spurs

another assumed factor for the impingement syndrome
might be a consequence rather that a primary cause

Spur formation increased dramatically with age.

anterior third of the acromion
at the insertion of the coracoacromial ligament
further decrease the volume available for supraspiantus tendon

anterior acromioplasty ; restore the function in most cases
sacrificing a good part of the acromial arch

long-term effect; unknown

Bigliani

Hooked acromion ; 70% of tears

Edelson and Taitz

More horizontal the acromion

the greater the degenerative changes

Increased degenerative changes

with increased length of the acromion

Aoki

Acromions with spur formation

flatter slope with increased pitting on the surface of GT.

Zuckerman

Rotator cuff tears

smaller gap between the humeral head and the CA Lig. smaller supraspinatus outlet flatter acromial tilt.

Chun

Intrusion of the Humeral Head to the supraspinatus outlet space

Burns and Whipple

Contact by the ant. tip of the acromion on the SS tendon and GT
Greater in the middle ranges of humeral elevation
60 degrees and 120 degrees.

Flatow et al; stereophotogrammetric

Acromion closest to the cuff tendons
between 60′ and 120′ of elevation
with contact focused at the supraspiantus insertion.
I/R 20′ ; more contact than neutral
Type III acromion ; increased contact

Computer simulation of acromioplasty

1). removing any anteroinferior ridges (spurs)
2). flattening the anterior third of the acromion
3). flattening the entire acromion flush with the posterior acromion

1); contact elimination 50%
2); 100% successfully removed impingment
3); deemed unnecessary
often destroyed the broad pattern of subacromial contact over the other cuff tendons and humeral head

Diffuse contact

Buffering
A passive, stabilizing role against superior humeral ascent

Dispute

Acromial morphology
cause of tendon degenration, or secondary change

AC joint

Osteophyte
Extreme I/R
Maximal adduction with I/R

Coracoid process

Rare; coracoid impingement syndrome

Soft tissue

Subacromial bursitis

Restricting free movement of gliding of rotator cuff example ; RA
In most instances, secondary to tendinopathy or impingement
No true inflammation

CA ligament

Stiffening & Thickening

not a primary lesion but a change occuring in reponse to continuous pressure

Watson

Thickening or stiffening of CA ligament

Ligament

Mainly fatty changes or microtears

Without any evidence of excessive collagen production

Compression

compression of the supraspinatus tendon by the overlying CA arch and causing injury has been termed impingement

pathologic contact ; impingement

physiologic contact ; buffering

<u>Intrinsic Causes</u>

Degenerative changes

Systemic diseases

Diabetes mellitus, Rheumatoid arthritis, Heavy manual work

Local factors

Intrinsic

Critical Zone, Vascularity, Wear-and-tear effect, aging

Extrinsic

Impingement

May Coexist

Degeneration of cuff tendons

Mostly in middle-aged and elderly individuals

In young persons; overuse - significant cause

Weakening of tendon

Disruption of fascilces

Formation of foci of granulation tissue

Dystrophic calcifications

Thinning of fascicles

Natural attempts to heal through cell and vessel proliferation

May lead to a swelling of the tendon

Cause of dysfuntion

Combination

mechanical weakening of the tendon

pain secondary to impingement caused by swollen tendon.

Degenerative changes

Decreased the ultimate tensile stress of the supraspiantus

Significant correlation

load at failure
the degree of degeneration as assessed histologically

Blood supply

Posterior circumflex humeral artery, Suprascapular artery
Infraspinatus, Teres minor
Anterior circumflex humeral artery, Thoracoacromial artery,
Anterosuperior cuff, Supraspinatus muscle

Critical zone of Codman

Pathologic changes in one particular portion half inch proximal to the palisades

Vascularity of the critical zone

Moseley and Goldie
blood supply from muscular and bone origin
anastomosed at that point of critical zone
No less vascularized
Rothman and Parke
Markedly undervascularized
Rathbun and Macnab
Hypoxia
not caused by the anatomic distribution of the vessels
but was dependent upon the position of the arm
Zone of avascularity ; wringing-out effect
Macnab
repeated bouts of hypoxia lead to degenerative changes

Hypovasclar Zone

Diminished vascularity in older
Dynamic decrease of vascularity
Adduction ; Rathbun and Macnab
Lifting a 1-kg weight
increase subacromail contact pressures
enough to block microcirculation
suggesting a dynamic vascular compromise
related to functional activities of daily living
Relative hypovascularity on the articualr side

Brookes and associates ; no hypovascularity in the supraspiantus

Wear-and-tear effect

Changes in the soft tissues

Capsule; becomes thin, then perforates
Subacromial bursa; loss of smooth lining, roughened, frayed
Tendons; separation and thinning of fasciles with destruction

Matrix changes

Aggrecan; increased in the supraspiantus
Subacromial impingment
tenocytes to shift the matirx to resisting compression tendon more

vulnerable to tensile failure

Aging

As early as third decade

Distal part > Proximal part

Earliest feature (Wilson and Duff)

altered staining of fiber bundles followed by fibrillation

With aging (Brewer)

Gradually loss of the integrity in the arrangement of fibers

Loss of staining properties

Loss of cellularity

Deformity of articular surface

Aging process except tear

Thinning and fibrillation of fascilces in the tendon porper

Broadening of endotenon spaces

Irregular thickening of the blue line,

Calcific deposits straying into the nonmineralized fibrocartilage Distorting architecture of fibrocartilage

Microtears involving fibroartilage

Disruption of the blue line by fibrovascular tissue

Collagen type III in degenerative lesions

Impairment of mechnical properties of the tendon

Trauma

Creates abnormally high demands on the soft tissues

Overuse

injuries to the glenoidal labrum

to the capsule

to the rotator cuff tendons

Subluxing shoulder

impingement occurs secondarily to instability.

Asymptomatic Rotator Cuff Tear

51% became symptomatic over a mean 2.8 years

39% incidence of tear progression

strong relationship between tear progression & development of sx (Yamaguchi, 1998)

REPAIR

Granulation tissue and cellular cap

Regardless of the age of the patient

Regardless of duration of preop. conservative treatment

Swiontowski et al

Laser Doppler flowmetry

hyperemic response at the torn margin.

Further evidence of repair activity

Considerable amount of collagen type III in the healing tendon

Cuff tears

an abundant amount of collagen type III
in perivascular areas of bursal wall
in the tendon tissue in the vicinity of the torn edge.

Morphological evidence of the early stage of repair
Persist in torn cuff tendons and the adjacent bursal wall
For as long as several years.

Injured tendon
Never fully regains its normal structure and strength (Viidik)
No histologic evidence that defects close spontaneously (Fukuda)
Deep partial tthickness tear; no natural healing (Chun)

Surgically repair
Dog experiment
Sharpey's fiber in 8 - 12 weeks
Monkey experiment
55% normal strength by 2 months
80% of normal strength at 1 year
60% of normal stiffness at 1 year

Pathogeneis of Cuff Disease
Neer ; mechanical
Ogata, Uhthoff, Ozaki - primary tendinopathy
prompted debridement of involved tendon

Debridement alone without decompression
a high proportion of poor results

Soslowski
Inrinsic degeneration perisist when mechanical insult was added

Consensus
Multifactorial

<u>CONSERVATIVE TREATMENT</u>

Objectives of Treatment
Pain free
Full range of motion
Normal strength
Normal function

Management of Rotator Cuff Disease
Primary Tx. of RCD; Conservative treatment
About 90% of RCD; Respond to Conservative Tx.

Advantages of Conservative Treatment
Safe
Not expensive

Avoid unnecessary Operation
Chance for evaluation of uncooperative patients

Three Areas of Concentration
- Decreasing inflammation
- Soft-tissue stretching
- Rotator cuff Strengthening

Decreasing Inflammation
- Rest
- Avoid offending mechanisms
- Antiinflammatory agent

Exercises
- Mainstay of nonsurgical treatment
- Home treatment
- No pain, Better gain !!!

Stiff Shoulder
- Limits the effect of strengthening exercises
- Tends to cause increased pain
- Posterior capsular contracture
  - Abnormal superior migration of the humeral head

Initial Goal of Strengthening Exercises
- A strong rotator cuff
- A relatively weak deltoid

AMC Protocol
- Essentially based on "Orthotherapy" of San Antonio
  - Active rest
  - NSAID, if necessary
  - Home therapy
    - Stretching exercises
      - Pendulum, Bar, Pulley, Wall climbing
    - Strengthening exercises
      - Six different color Therabands
      - Rotator cuff & parascapular stabilizers

AMC Experience
- March, 1995 ~ December, 1996
- 617 cases with rotator cuff disease
- More than three months; 175 patients
- Satisfactory; 145/175 (83%)
- Unsatisfactory; 30/175 (17%) - 17/30; Surgery
- Surgery during the same period; 54 cases from 617 cases (9%)