Recent Topics in Shoulder Joint
Suture anchors in the year 2001

최 창 혁
대구가톨릭의대

A. Suture anchor

1. Usefulness of suture anchor

Shoulder stabilization
Rotator cuff repair
Reattachment of other tendons to bone

2. Options of suture anchor

Size: minor and major diameters
Shape
Composition: biodegradability
Method of insertion
Radiopacity
Holding strength

3. Two areas of Anchor Development

1) Biodegradable anchors:

Polyglycolic acid(PGA),
Poly L-lactic acid(PLLA)
PGA-PLLA copolymer

2) Mini anchors

Drill holes or minor diameters of <2.2mm

4. Anchor comparison

Failure strength

Failure mode

Eyelet size

Minor and major diameters

Drill hole sizes

5. Evaluation of anchors

Pullout strength

Mode of failure

Suture size acceptance

6. Mode of Failure

Anchors are stronger than the breaking strength of the suture

Metal anchors > Biodegradable anchors > sutures

1) Predominant failure mode

a) Biodegradable anchors all failed > 2 #2 Ethibond(30 lb)

Except: Biofix and TAG Wedges 2 and 3

Biodegradable screw anchors: eyelet cutout

Biodegradable nonscrew anchors: anchor pullout

b) Mini anchors: <2.2 mm, suture<#2

Metal (except TAG wedge 2 and Bio-anchor)

Screw perform well and usually fail by anchor eyelet cutout

NonscrewFail usually by anchor pullout

(except ROC 1.9, SB 2wire cutout)

2) Clinical failure

Ligament

Bone

Suture anchor

Suture

Weakest area: Suture-tendon interface

- Suture breakage or Suture cutting through the tendon

7. Advantage of Suture anchor

Easier and quicker to insert

More reliable form of fixation than a bone tunnel

More consistent result

Cyclic loading: repair laxity

"no" profile of anchors

1) Advantage of mini anchor

Technological advance: good fixation strength

Smaller implant

Smaller bone defect

Place more anchors in a single area

Applicability to smaller bones

2) Advantage of Biodegradable Implant

Secure initial fixation strength

No need for implant removal

Easy revision surgery

MRI is not distorted

Earlier functional load

B. Biodegradable implants

Materials that show disintegration after implantation & subsquent complete excretion

Materials : Sutures, Staples, Tacks, Anchors,
Interference screws, Devices for meniscal repair

1. Basic characteristics

1) Biology : In Vivo Degradation
Biocompatibility
Osseous replacement

2) Physical properties

3) Mechanical properties

1) Biology

* Degradation kinetics

a) Mechanism

Biodegradable polymer(poly--hydroxy acids)
→ hydrolytic chain scission(water uptake)
→ fragmentation
→ phagocytosis(macrophage & PML)
Polymeric lactic acid oligomers
→ Krebs cycle
→ carbon dioxide & water Hollinger, 1986

b) Factors:

Polymer choice
Molecular weight(MW)
Sterilization, Implant size
Self reinforcement
Processing technique

Degradation according to polymer

Major interest: PLLA & PGA
Slow or intermediate degrading M.
PLLA, PLLA-co-PDLLA, PDLLA
– Maintain mechanical strength during proper tissue healing

Rapid degrading M.

PDS, PGA, PGA-co-TMC, PDLLA-co-PGA
– Significant loss of mechanical strength

c) 5 phases of degradation(pistner et al. 1997)

1. Healing phase
2. Latency phase

3. Protracted resorptive phase
4. Progressive resorptive phase
5. Recovery phase

d) Degradation kinetics vs. clearing capacity Maximum extent of FBR:
PGA(12 weeks after surgery)
PDS, PGA-co-TMC, PDLLA-co-PGA(between 8 and 24 weeks after implantation)
PLLA, PLLA-co-PDLLA(> 1 & 2 years))
Osteolytic changes: Slow degrading & amorphous polymers
1. insufficient drainage of byproducts
2. overloaded cellular clearing capacities

e) Long term fate
Complete degradation does not occur within an appropriate time
Late hydrolytic degradation depends on the degree of materials crystallinity

* Biocompatibility

a) Nonspecific foreign body reaction
PGA implants
: intensive inflammatory tissue response
Better biocompatibility
: PDS, PLLA, some PGA copolymer
Standardized classification system: incidence & severity of tissue reaction

b) Classification of Adverse reaction(Hoffmann et al. & Weiler et al.)
Adverse reaction: crystalline nature or low PH of the degradation byproducts
1. Extra-articular : PGA> PDS or PLLA
2. Intra-articular: Associate with loosened fragments or wear debris released before implant degradation
PGA-co-TMC tack in shoulder joint
→ high incidencde of LOM with synovial adhesions
(Warner, 1995., Bennett, 1998, Edwards,1994., Imhoff, 1998)
3. Osteolytic lesion: Bone resorption stimulated by the byproducts,
Mild osteolytic changes to cystic-like resorption cavities
PGA> PLLA, PDLLA-co-PGA, PGA-co-TMC, PLLA
(Weiler, 1996)

* Osseous replacement

To facilitate uncompromised revision surgery, a complete osseous replacement should occur within a 2- to 3-yr.

a) Pattern of Osseous replacement

1) Osseous ingrowth while the implant is degrading(Majola,1992)

: PLLA-co-PDLLA(70:30), PLLA/PDLLA

2) Osseous ingrowth in the center of the former implant site(Weiler, 1996)

3) Osseous scarring of the former implant site(Weiler, 1996)

b) Faster a material degrade, the earlier the osseous replacement

PDLLA-co-PGA, PLLA-co-PDLLA,PDLLA: faster

PLLA : several years,

No reports of complete osseous replacement

Gatzka, 1997, PLLA:6yrs(-) ankle frecture

Pistner, 1997, injection molded PLLA

& PLLA-co-PDLLA-- 150 weeks(+)

2. Physical properties

: Molecular weight, intrinsic viscosity, crystallinity, melting and glass transition temperature

Absorbable polymers with low crystallinity : better for medical applications

3. Mechanical properties

* Modulus of elasticity(stiffness of polymer)

: depends primarily on the crystallinity

* Ductility (percent elongation):

* Mechanical strength

L-PLA : Tensile strength: 11.4 82.7MPa

Flexural strength: 45 145 Mpa

Orthopaedic implant(load) >MW 100kd

PGA : more brittle and degrade faster than PLA

Initial strength : 57 69 Mpa

PLA-PGA polymers with fibers

: increase flexural strength

Wet strength half-life

:PGA2 weeks

PLAover 6months for L-PLA (higher hydrophobicity)

C. Suture anchor failure vs. bone density to proximal humerus

1. Pull-out force

Location: No difference between GT and LT

GT : anterior and posterior difference

Post.: 154 N > Ant.: 96 N

LT: Ant185, post177

Humeral neck: Ant170, post174

No correlation between BMD and anchor load to failure strength

: Pullout strength(ant GT< post. GT),

Equivalent BMD

Influence of osteoporosis

RCR<IF of proximal humerus fracture

Length of POP immobilization

2. Depth of anchor insertion

Deeper insertion--> Higher load to failure

3. Suture anchor vs. Bone tunnel

: more determinant of the bone strength than the screw type suture anchor

4. Screw-type suture anchor

: most efficient devices in terms to load to failure versus diameter

D. Key steps in Clinical application

1. Site exposure

2. Drill hole placement

3. Anchor insertion

Screw anchors:Self-tapping or predrilling
Nonscrew anchors: Drilling or impaction

4. Suture placement : Anchor and instrumentation dependant

Tendon-Anchor-Bone: Mitec G2
Suture anchor-Bone-Tendon: mc
Suture anchor-Tendon-Bone: Corkscrew and Fastak, MiniHarpoon

5. Knot tying

* Rotator cuff repair
Suture selection
Type of tendon stitch: simple or mattress
Method of suture fixation: bone tunnel or suture anchor
Actual location of fixation in the proximal humerus
Angle of anchor insertion
* Anterior shoulder reconstruction
Mitek GII anchors
:repetitive submaximal load reduce the pullout strength
Pullout strength difference between the superior and inferior portion of the glenoid
(Superior Q: 237N Inferior Q: 126N)
(Merrick J. Wetzler, 1996)

* Open Bankart procedure absorbable suture anchor
Degenerative changes: increase over time
Reactions in bone did not affect the clinical outcome
:invisible drill holes and visible cystic formation
Traumatic anterior dislocation will cause
degenerative changes whether or not stabilization is achieved

(Lars Ejerhed, 2000)

E. Future Considerations

Long term study of the implant degradation & osseous replacement
Physiologic & mechanical changes during degradation process
Influence of osteoporosis & immobilization
Reactions in bone and cartilage