

# The Use of Acellular Dermal Matrices in Tendon Repair

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# Tendon Injuries

- Tendon injuries of the lower extremity are very common among patients leading active lifestyles
- According to the Centers for Disease Control and Prevention lower extremity injuries were responsible for 13.5% of the 37.8 million injury related visits to the emergency room in 2010
- An astounding 1.5 million visits involved injuries of the ankle and foot alone

# Tendon Injuries

- Tendon disorders often lead to significant disability, pain, increased cost, and loss of productivity
- Tendon tears and ruptures can occur in otherwise healthy appearing tissues that become acutely overloaded
- Tendinitis or tendinosis can occur in tissues exposed to over use conditions

# Tendon Injuries

- The healing potential depends of the anatomic location and the quality of the healing environment.
- Normal tendon healing typically conforms to the standard wound healing pattern characterized by:
  - an initial inflammatory phase
  - followed by a proliferative phase
  - finally a remodeling phase
- If the normal pattern is altered it can lead to prolonged healing times and long-term permanent dysfunction of the limb

# Acellular Dermal Matrices (ADMs)

- Tendon augmentation and repair utilizing decellularized human skin otherwise known as acellular dermal matrices (ADM) have been well reported in the literature
- In particular ADM scaffold products have been shown to increase cell infiltration, host tissue integration, and vascularization

# Acellular Dermal Matrix

Throughout the processing of the graft retains its growth factors, native collagen scaffold and elastin giving superior strength, but is rendered sterile & biocompatible

- It is therefore the ADMs are a great choice to provide supplemental support for tendon repair and augmentation

# Benefits to adding ADMs in tendon procedures

- Laboratory studies have proven once incorporated ADMs contribute to superior suture retention strength compared to competitive products on the market
- In my experience the use of ADMs helps to increase the strength of the tendon post-op & aids in securing the tendon-suture interface
- ADMs can help to increase healing potential & decrease healing time

# Achilles Tendon Injuries

- The Achilles tendon is one of the most common tendons to tear or rupture despite being the thickest tendon in the human body
- Acute injuries frequently occur while participating in sports, especially in patients over the age of 30 who are only occasional athletic participants
- Achilles tendon injuries are frequently misdiagnosed which delays needed treatment and creates neglected tears and ruptures

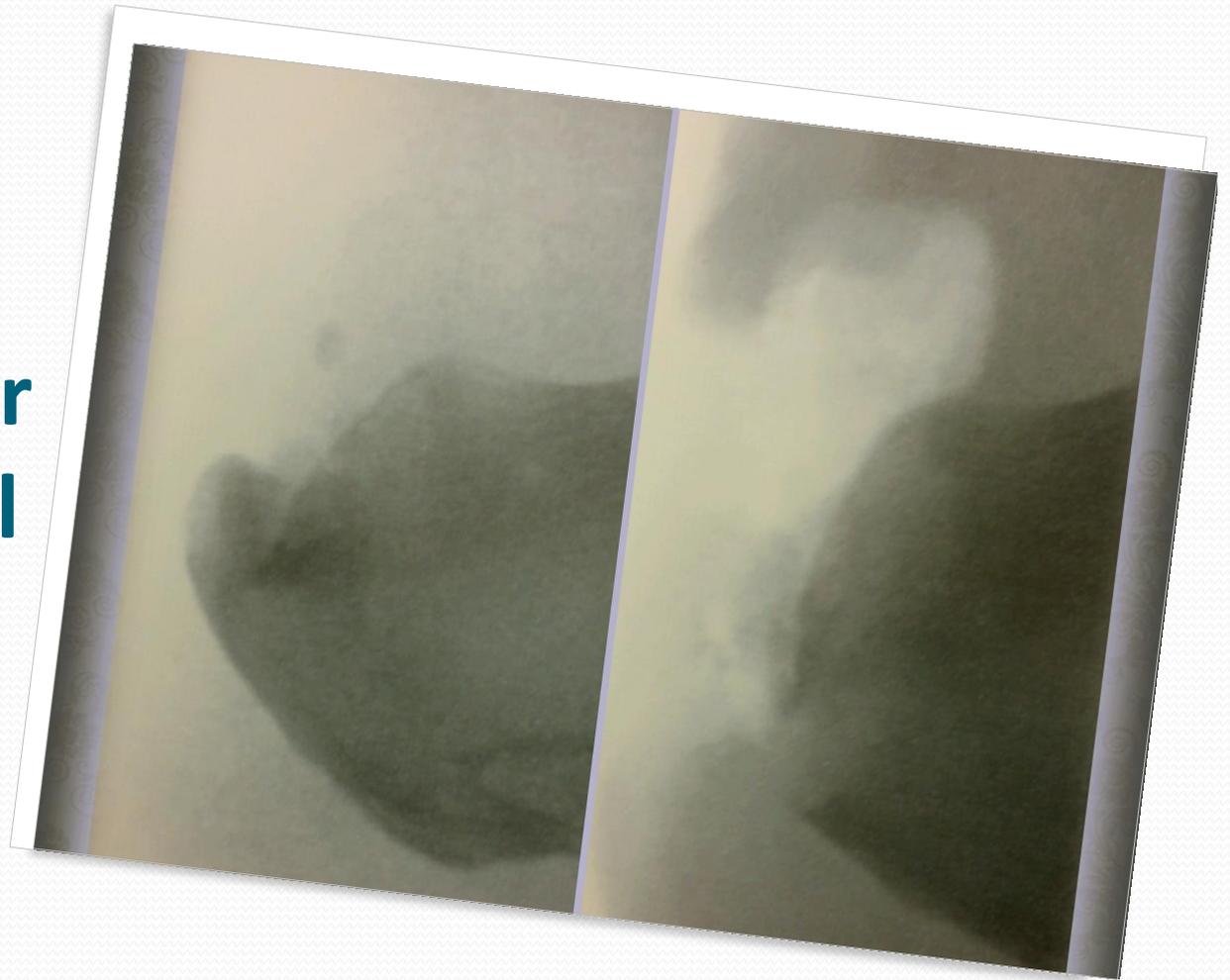
# Achilles Tendon Repair Study

- Nine patients underwent Achilles tendon repair with ADM augmentation from September 2012 through December 2014
- Patients were medically cleared for surgical intervention after a tendon tear or rupture was confirmed by (MRI)
- All patients were taken into the operating room and placed in a prone position. General anesthesia along with a local nerve block was administered for patient comfort

# Achilles Tendon Repair Study

- A primary repair of the tear or ruptured tendon was then performed using 3-0 vicryl suture
- If the tendon was ruptured at the insertion or if the tendon must be removed from the attachment on the calcaneus to perform a debridement and repair, it was reattached
- The ADM was cut to size to overlay the primary tendon repair
- The ADM was then sutured into place using an interrupted stitch pattern with 3-0 vicryl suture material
- The soft tissue layers were reapproximated using atraumatic surgical technique

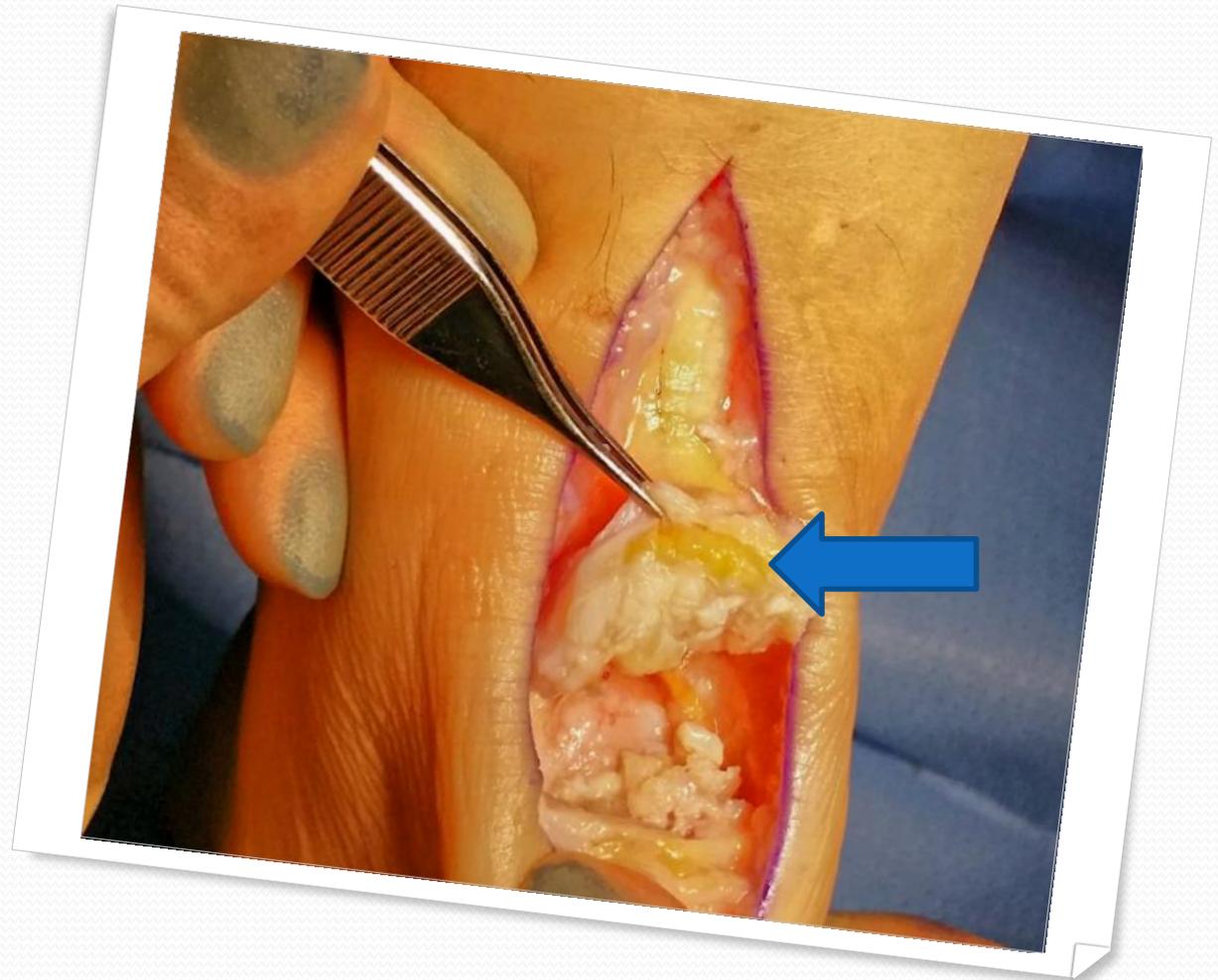
# Achilles Tendon Repair with Removal of Haglund's Deformity



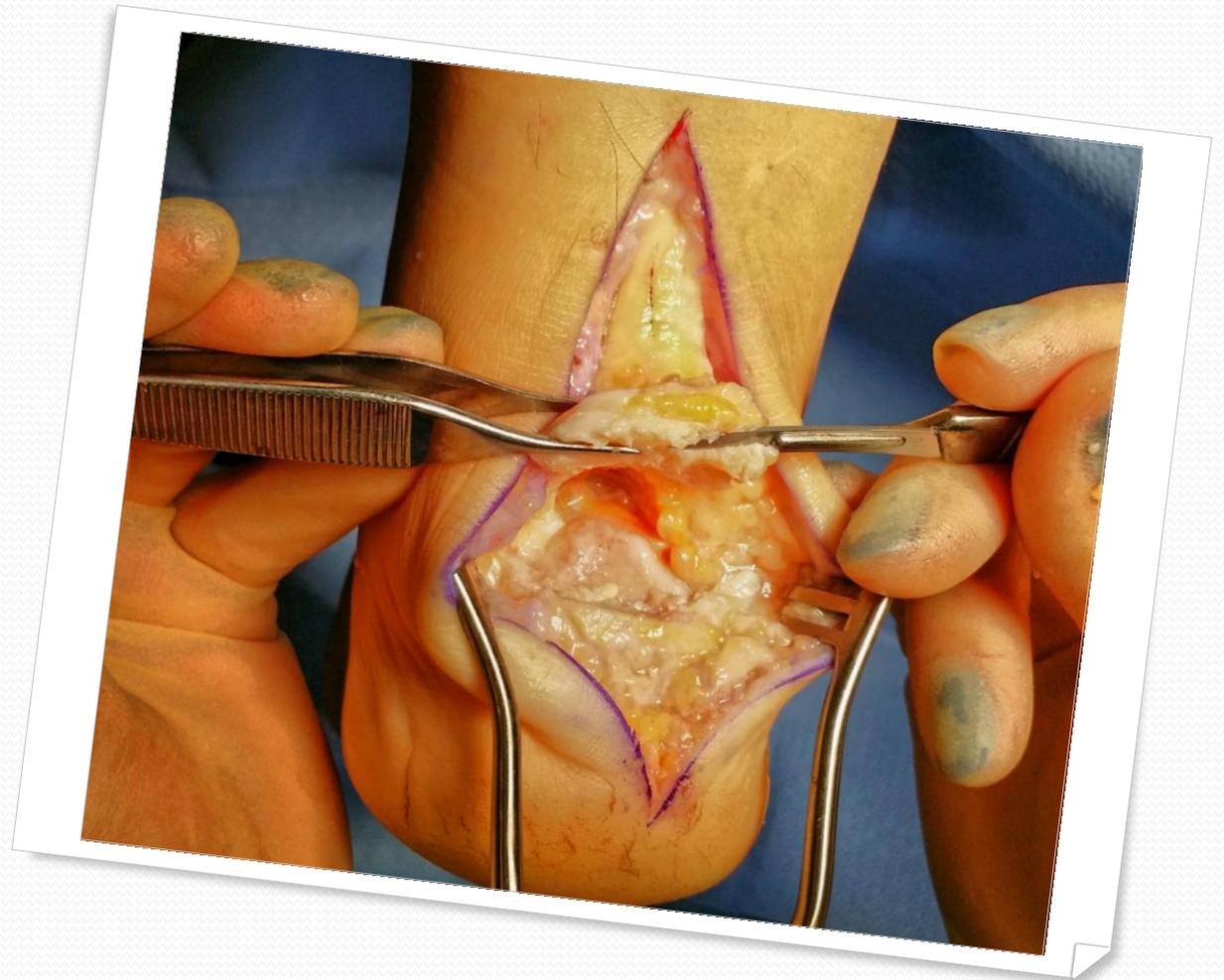
**Chronic wear  
and micro-  
tears of the  
Achilles tendon  
have lead to  
mucoid  
degeneration  
and scar tissue  
formation**



**Notice the significant partial thickness, fibrotic, degenerative changes within the substance of the Achilles**



**After complete resection of the Haglund's deformity, a thorough debridement of devitalized and fibrotic tendon tissue is performed**



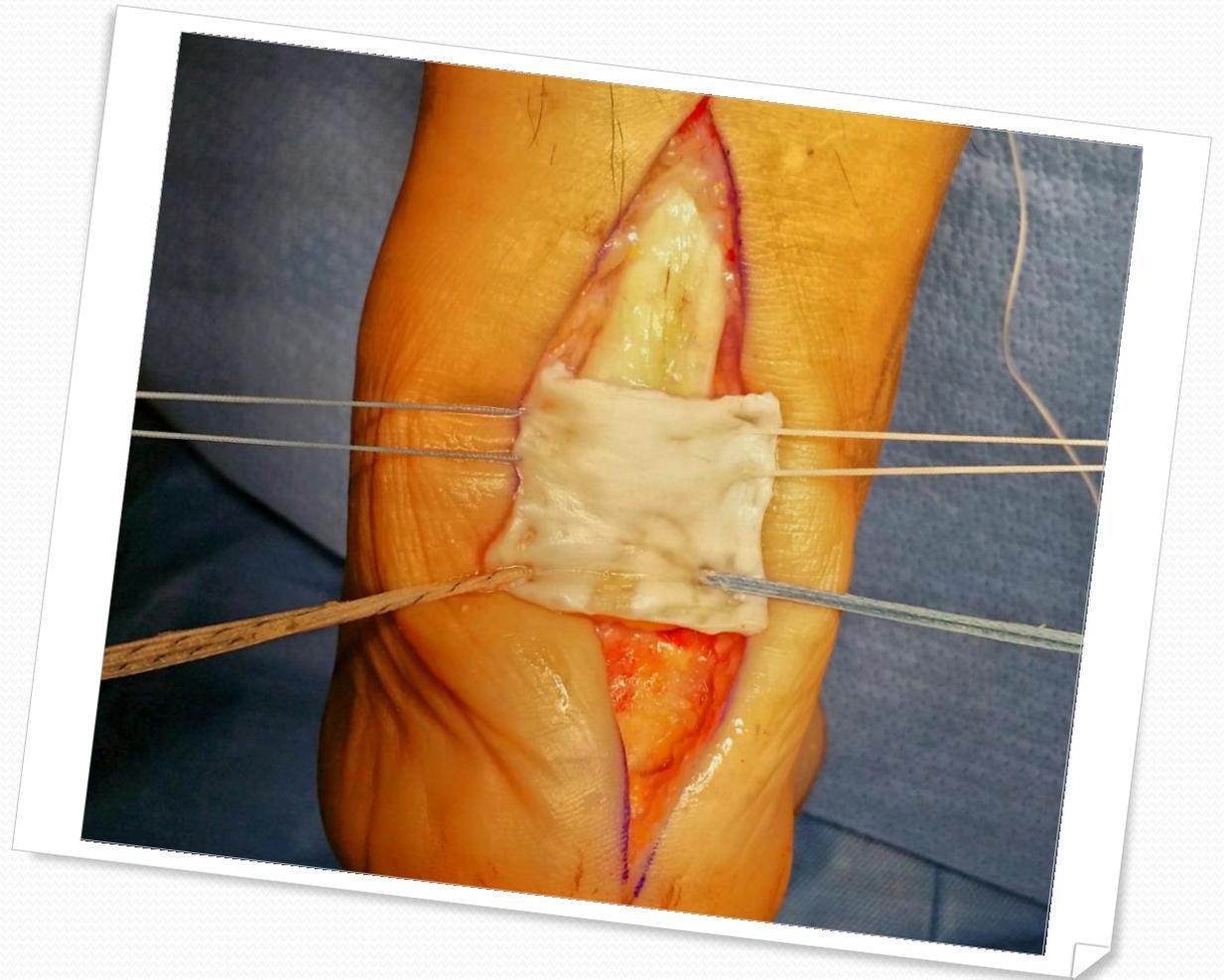
**Once the proximal anchors are placed the ADM graft receives a quick saline rinse and is cut to fit over the area of the debrided Achilles tendon**



**I then use a  
free needle  
and the  
sutures  
provided in  
the anchor  
construct to  
tether the  
ADM to the  
tendon**



**The suture is then passed to secure the distal aspect of the ADM to the Achilles**



**After the distal anchors of the system are placed into the calcaneus the suture is then hand tied to secure the graft onto the tendon proximally**



**You can appreciate how nicely the ADM graft can be incorporated into the this technique thus providing additional stability of the repair and increasing the healing potential for the patient**



# Retrospective Analysis\*

- The Foot Function Index-Revised (FFI-R) long form was used to evaluate patients at an average of 18 months follow-up
- This validated test was scored using the method detailed in Riskowski et al.
- Any questions that were unanswered and left blank by the patient were not counted in the score of that individual patient

\*Accepted by JFAS, pending publication

# Results

- Nine patients underwent an Achilles tendon repair augmented with ADM
- Patients ranged in age from 23-68 years old and consisted of four males and five females
- All nine patients completed the Foot Function Index-Revised (FFI-R) long form with an average 18 months (minimum 12 months) follow-up
- Table 1 shows the sub scores and cumulative score for each patient

# Results

Table 1. Foot Function Index-Revised Long Form Scores

	Pain Score	Stiffness Score	Difficulty Score	Activity Score	Personnel Score	Cumulative Score
Patient 1	24%	25%	25%	40%	24%	27%
Patient 2	48%	38%	35%	40%	29%	36%
Patient 3	24%	28%	25%	40%	29%	29%
Patient 4	26%	25%	25%	49%	29%	30%
Patient 5*	91%	81%	81%	30%	74%	73%
Patient 6	28%	38%	25%	58%	35%	35%
Patient 7	43%	50%	25%	40%	24%	33%
Patient 8	52%	44%	25%	58%	35%	39%
Patient 9	43%	31%	25%	49%	35%	35%
Total	36%	35%	26%	47%	30%	33.0% ± 4.2**
Rao et al. 2009						31.1% ± 9.8
Rao et al. 2010						31% ± 10

# Results

- A thorough search of the literature did not return any reports of Achilles tendon repairs that were evaluated using the FFI
- This absence was also supported by a recent meta-analysis (Budiman-Mak 2013)
- While the lack of similar studies makes comparison difficult, the results presented here could provide a baseline for evaluation with future studies

# Results

- Although it is not an ideal substitute, other foot and ankle studies have reported scores of  $31.1 \pm 9.8$  (Rao 2009),  $31 \pm 10$  (Rao 2010), and 35.2 (Fishman 2012) which suggested the average score reported here of  $33 \pm 4.2$  may indicate a level of success
- The smaller standard deviation score may show a higher degree of consistent outcomes among the Achilles tendon repair patients

# Results

- Soon after the survey was completed, patient 5 was diagnosed with multiple sclerosis and this likely had a large effect on their answers
- Since the diagnosis of multiple sclerosis was unrelated to the ADM augmentation, this patient's results were not included in the average score or data analysis
- There were no re-ruptures or post-operative complications for any patients

# Results

- All nine patients successfully underwent augmented Achilles tendon repair surgery
- No patients showed any sign of infection or had an adverse reaction to the ADM augment
- One patient was removed from data analysis due to the diagnosis of an unrelated condition that would have severely affected the results

# ADM Histology

- Patient fell & re-ruptured Achilles 2 months post-operatively
  - Re-rupture occurred at primary repair site
- Revision done (~1 mo later), at which time ADM was removed
  - Both host tendon and ADM were sectioned into two specimens
  - ADM was adherent to host tissue at removal

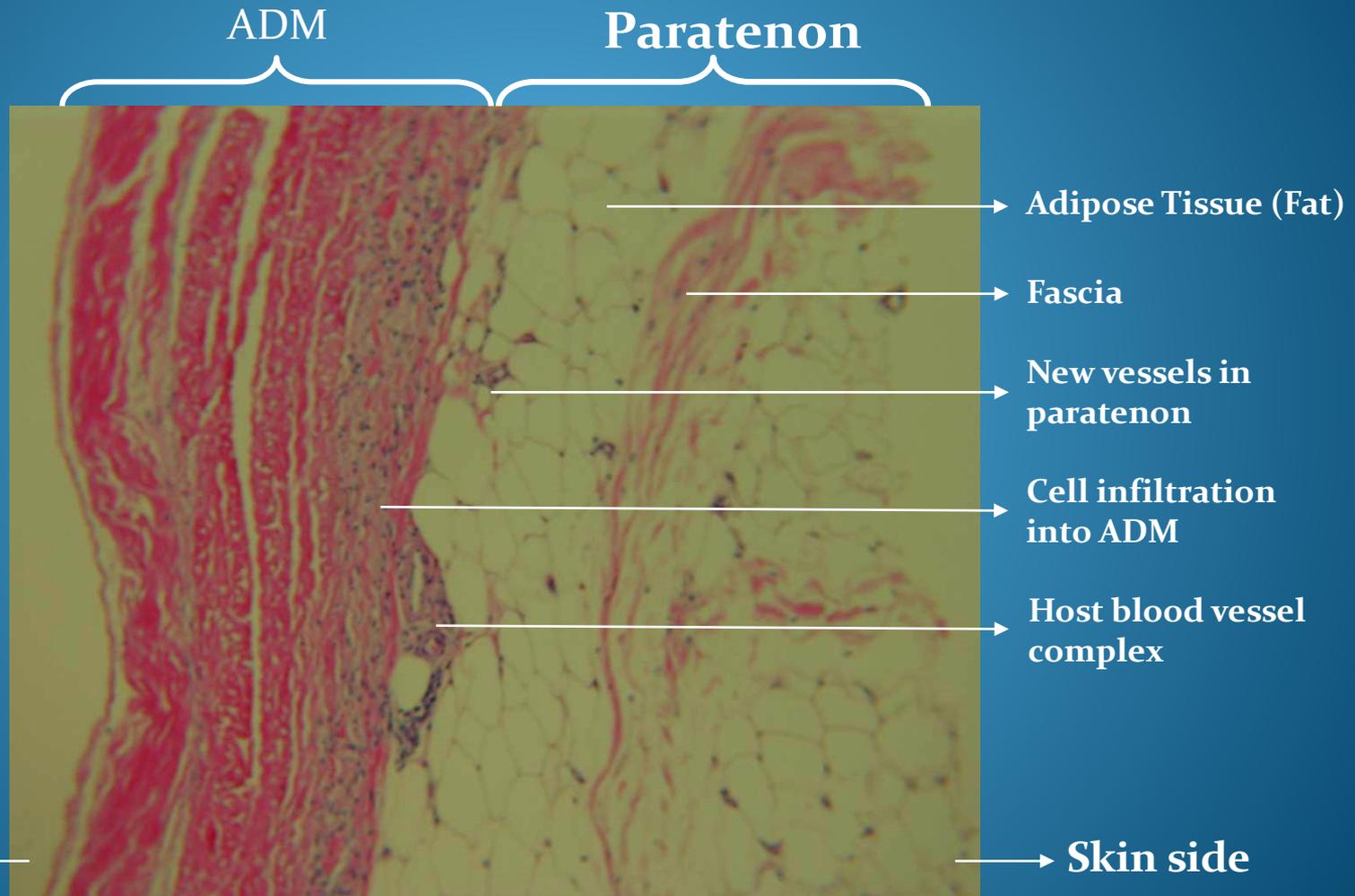
# ADM Histology

- All sections showed nice attachment of paratenon to the ADM
  - **NO** evidence of any inflammatory response seen in any area
  - Robust vascularization seen in graft-paratenon interface
  - Active infiltration of cells seen from paratenon into graft
  - Infiltrating cells appear synovial (mesenchymal) in nature
  - Neo-vascularization seen within cell infiltrated areas
  - Revitalization of graft was directional (from paratenon side)
  - Up to 60% of graft vitalized (new cells) in some areas
- [Biological incorporation of human acellular dermal matrix used in Achilles tendon repair.](#)
- Bertasi G, Cole W, Samsell B, Qin X, Moore M.
- Cell Tissue Bank. 2017 Apr 28. doi: 10.1007/s10561-017-9628-3.

# Histology Results

- As expected, remodeling was being driven from paratenon (directional)
- ADM showed high levels of compatibility
  - Absence of inflammation (in graft and host tissue)
  - Presence of active vascularization (within and around graft)
  - Infiltration of appropriate host cells into graft substance
- Low and High magnification images are represented
  - Low mag images show large area of graft-paratenon interface
  - High mag images concentrate on remodeling features

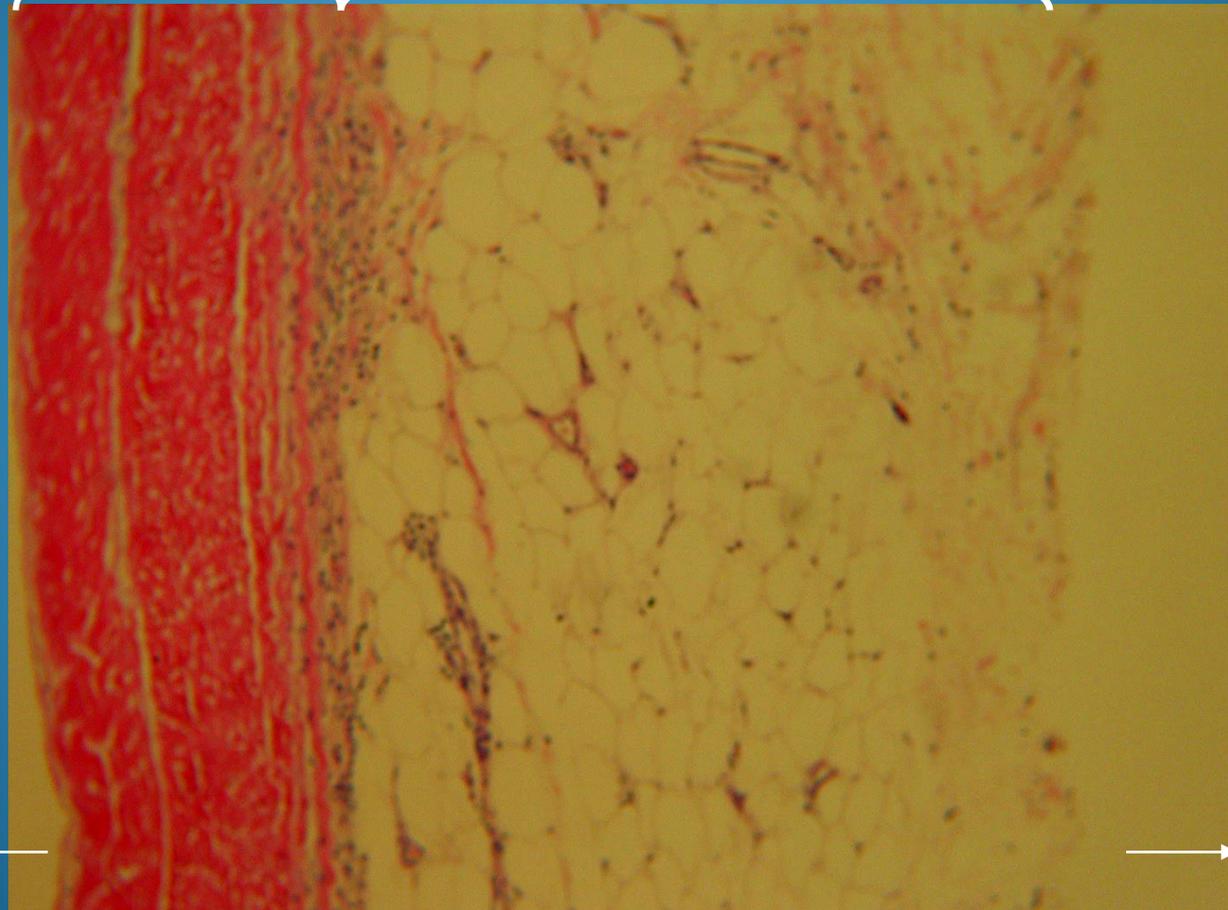
# Graft-paratenon Interface – Section 1 (Low mag)



# Graft-paratenon Interface – Section 2 (Low mag)

ADM

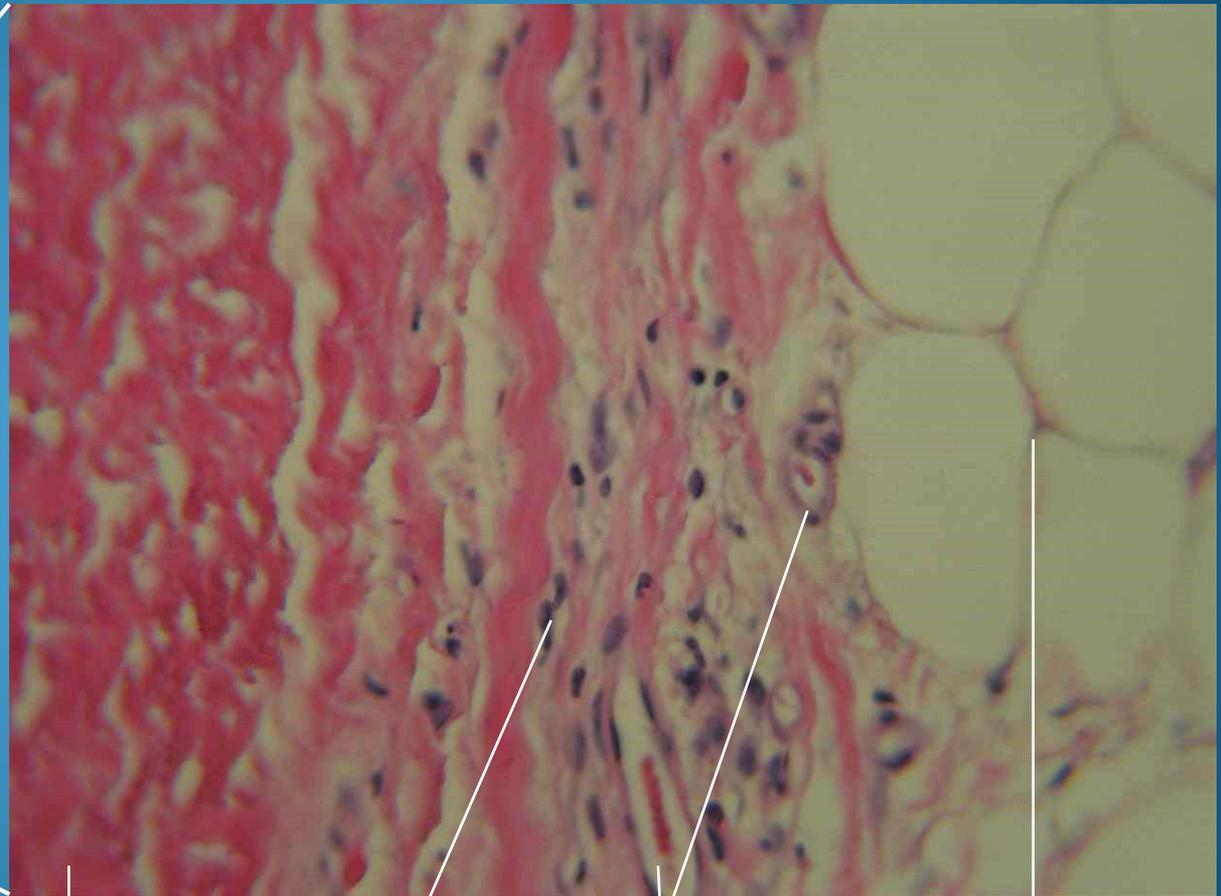
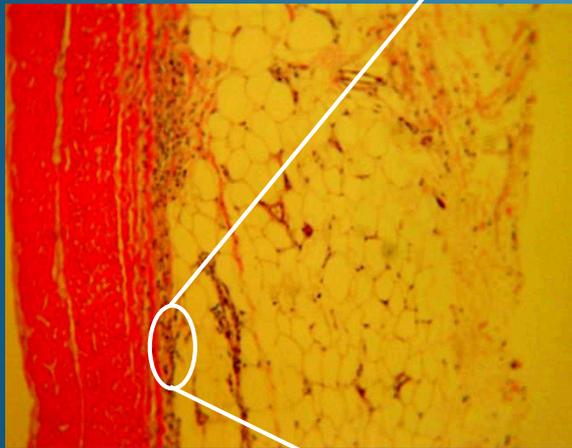
Paratenon



Tendon side ←

→ Skin side

# Graft-paratenon Interface – Section 2 (Hi mag)



ADM

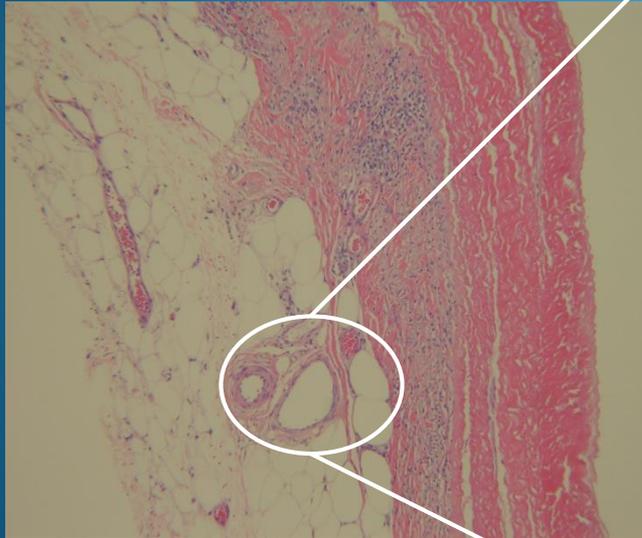
Tenocytes

Neo blood vessels

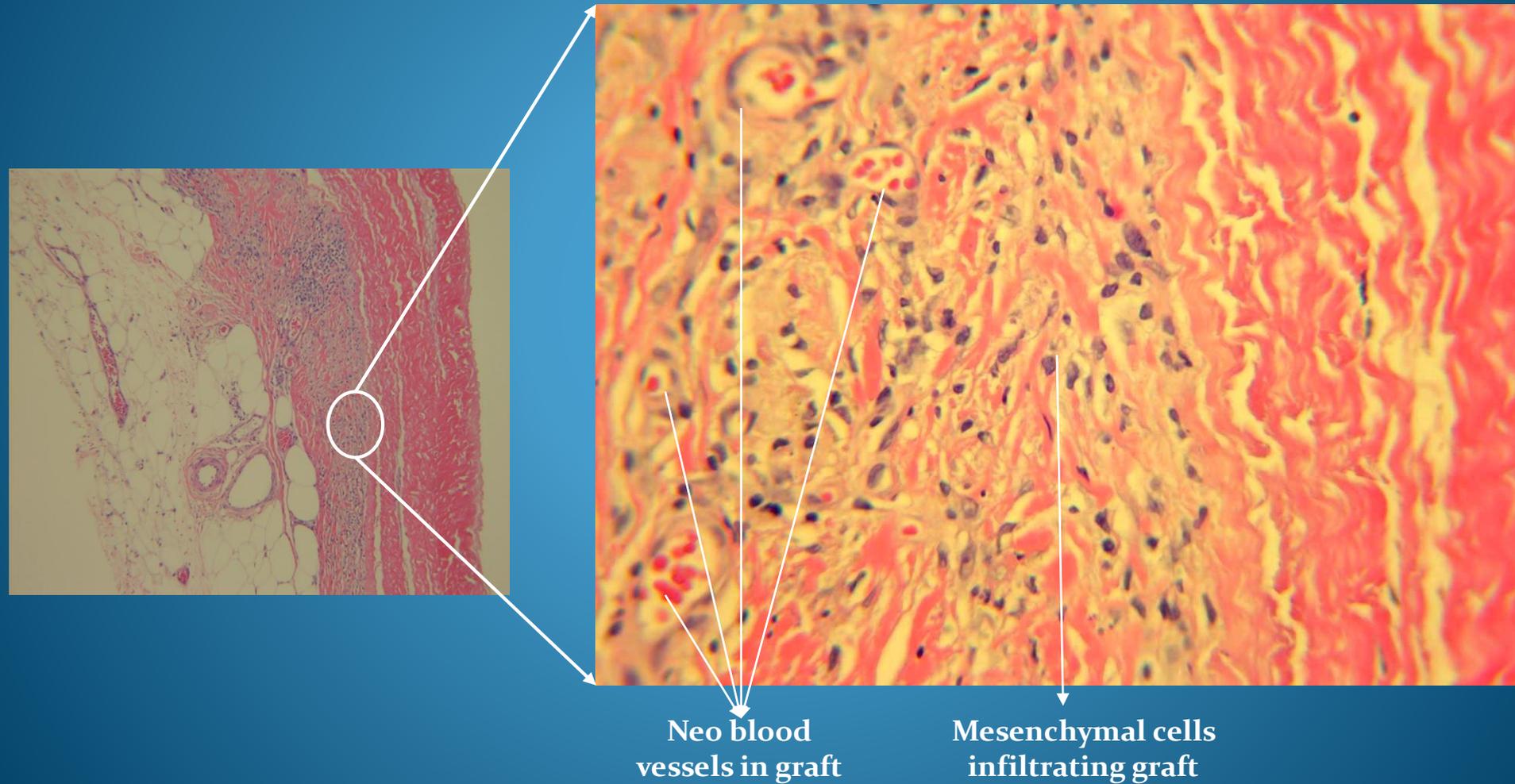
Fat cells from paratenon

# Graft-paratenon Interface – Section 3 (Hi mag)

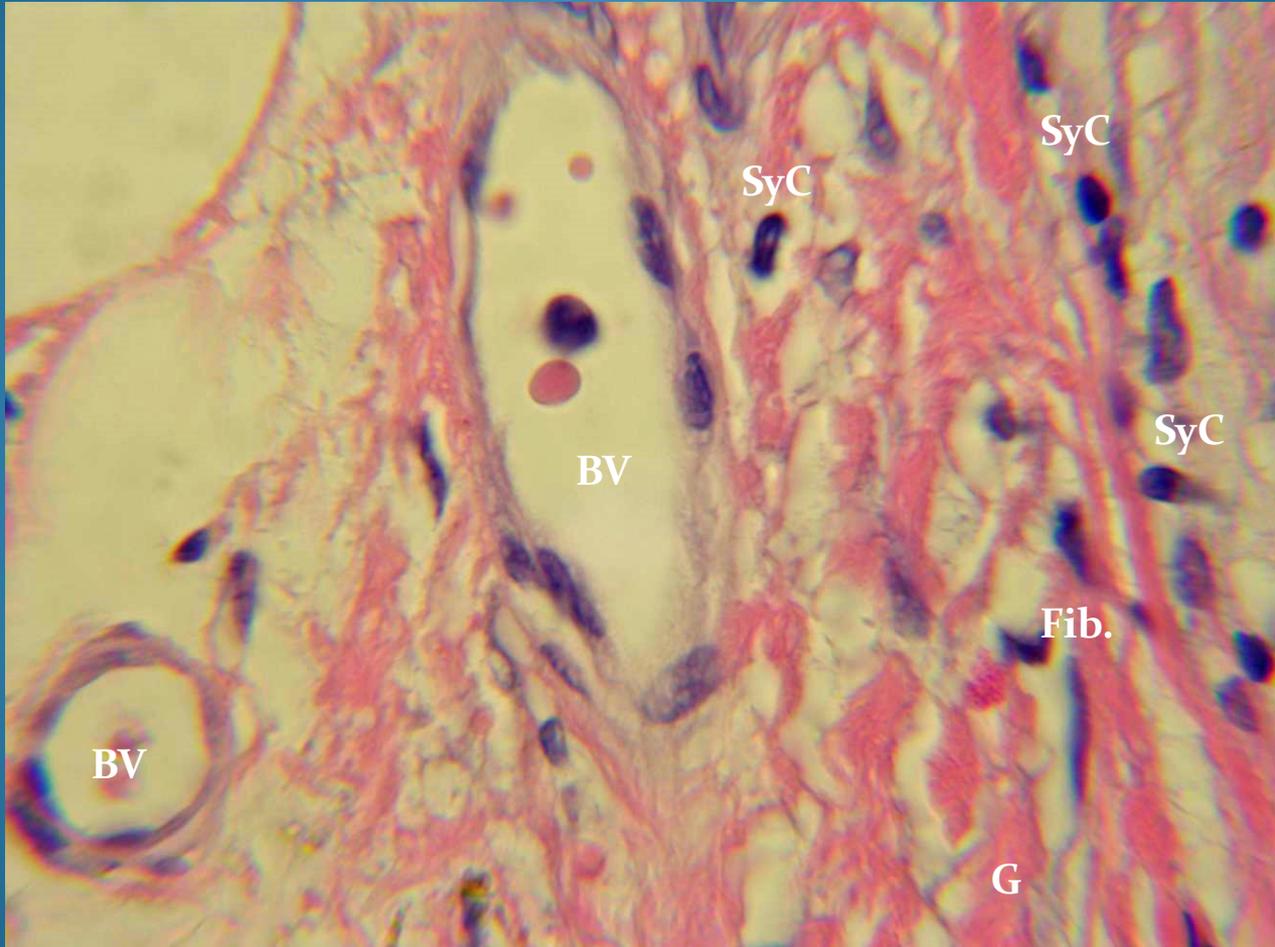
Host blood vessel complex from  
paratenon



# Graft-paratenon Interface – Section 3 (Hi mag)



# Graft Substance – Hi Mag Image



High magnification image of remodeling graft (G) showing appearance of new blood vessels (BV), and cells of synovial (SyC) and fibroblastic (Fib) phenotypes.

# Histology Summary

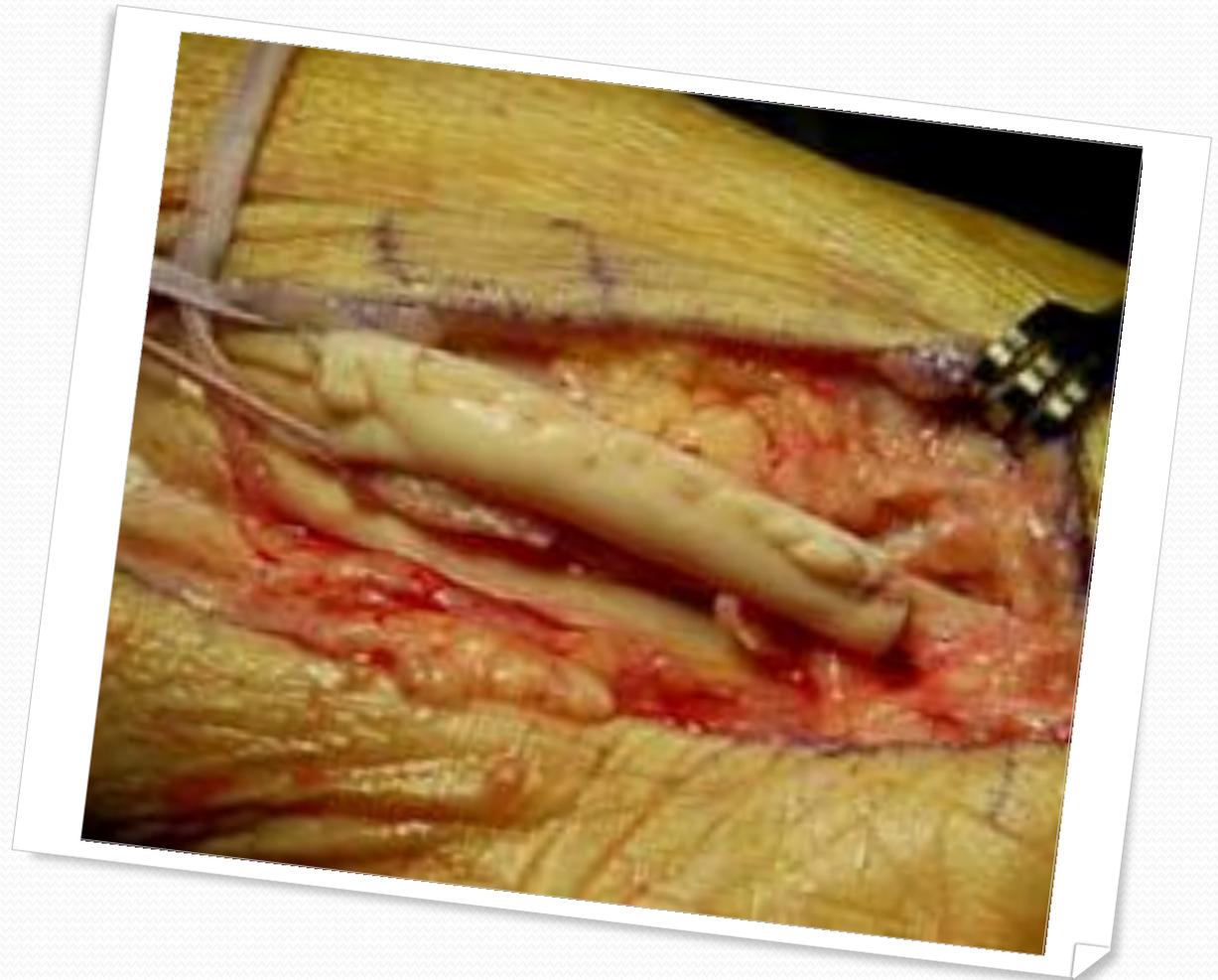
- All samples showed incorporation of the ADM with the paratenon
- There was no evidence of any inflammation response detected
- Robust neovascularization was noted at the ADM paratenon interface
- These histologic findings are consistent with the hypothesis that the intact acellular matrix of collagen, elastin, and growth factors provides an effective supplemental scaffold in which the body's natural repair process can incorporate to strengthen the tendon paratenon interface during healing

# Peroneal Tendon Repair



I also use ADMs in the repair of linear tears in the peroneal tendons.

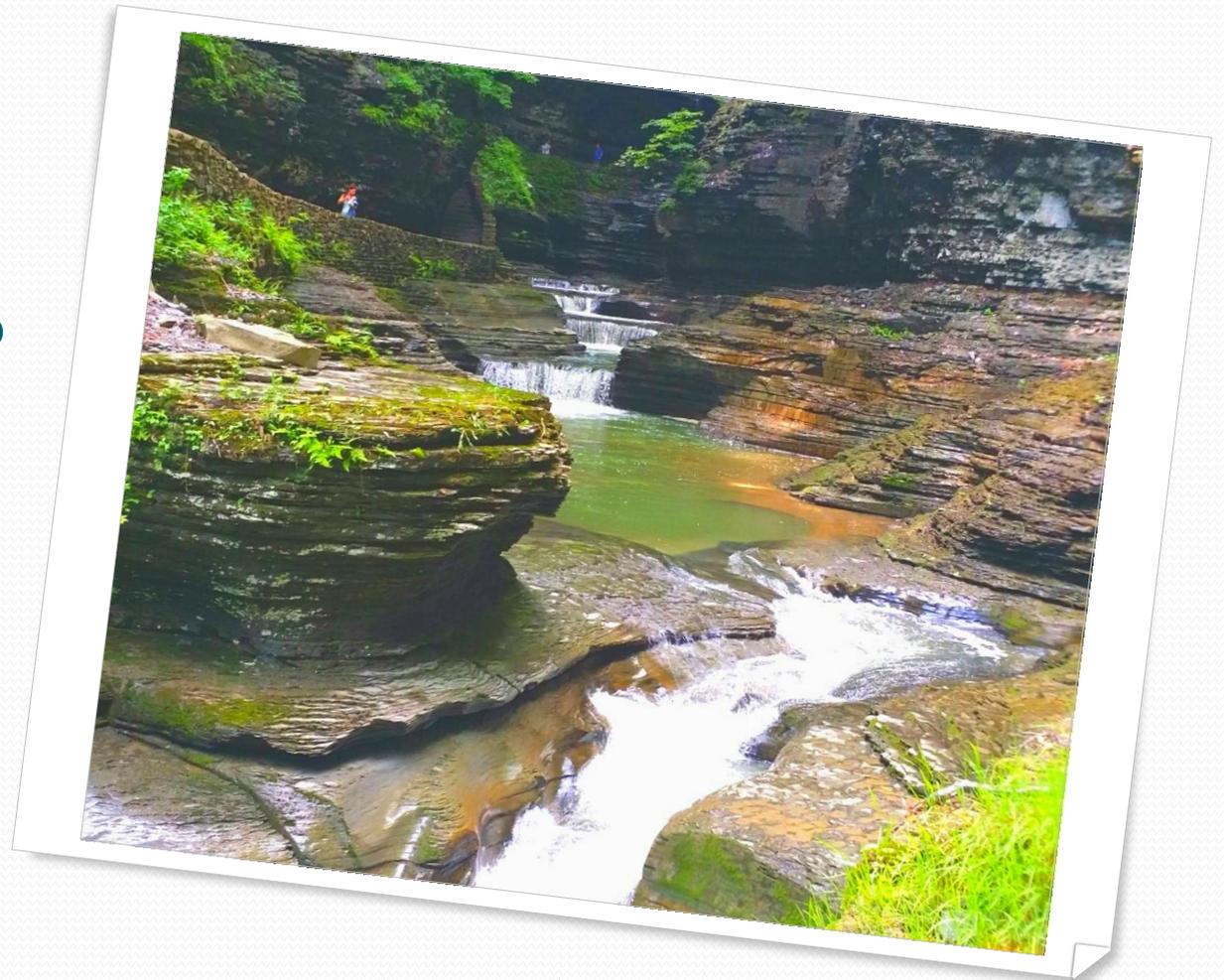
After primarily suturing the structural abnormality, I then wrap the graft around the tendon in a 'burrito' technique



# Post-op Care

- An posterior splint is applied post-operatively and worn for 2-3 weeks
- Patient is non-weight bearing during this time frame
- Once initial clinical signs of healing are noted the patient is weaned into a removable cast boot and allowed to ambulate
- At roughly 6-8 weeks the patient is then allowed to begin to walk in regular shoes
- Physical therapy and strength training may be begun at this time if necessary

**Any  
Questions?**



Watkins Glen  
State Park