Plantar plate repair & MTP joint instability: comparing surgical techniques to optimize outcomes

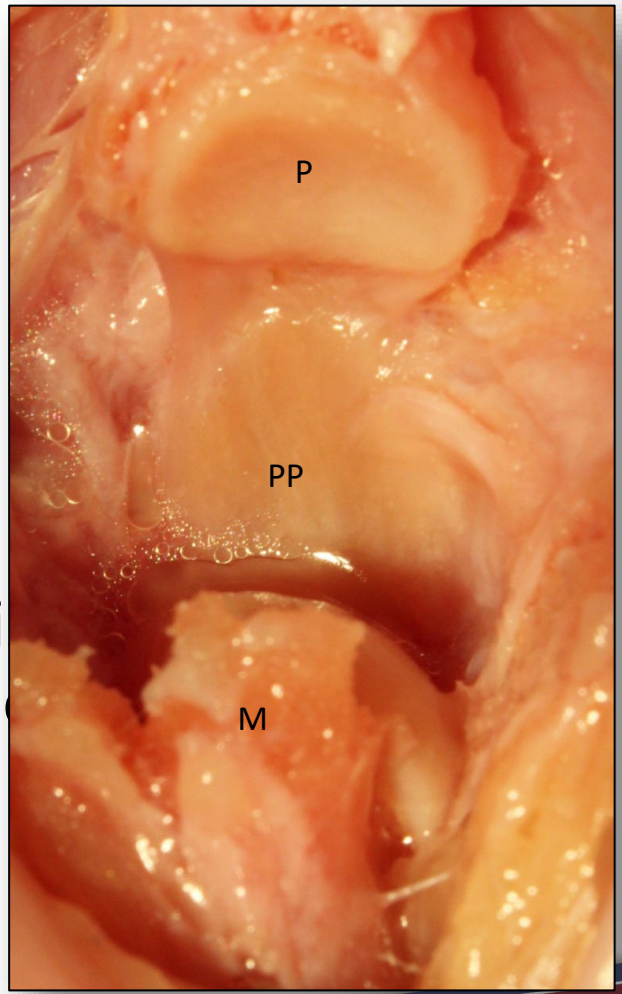
Erin E Klein, DPM, MS, FACFAS, DABPM
Fellowship Trained Foot & Ankle Surgeon
Weil Foot & Ankle Institute
Mount Prospect, Illinois, USA

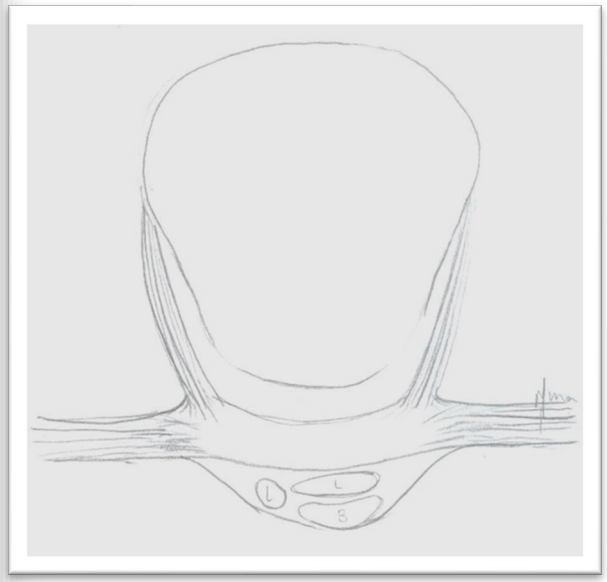
Clinical Instructor, Dr William M Scholl College of Podiatric Medicine at
Rosalind Franklin University of Medicine and Science
North Chicago, Illinois, USA

WEIL FOOT & ANKLE

The plantar plate

- Primary stabilizer of the MTP joint
- Fibrocartilage
  - Type 1 collagen
  - Dorsal 2/3^{rds}: longitudinal organization with interwoven appearance
  - Plantar 1/3rd: transverse organi continuous with deep transvers intermetatarsal ligament
  - No elastin fibers



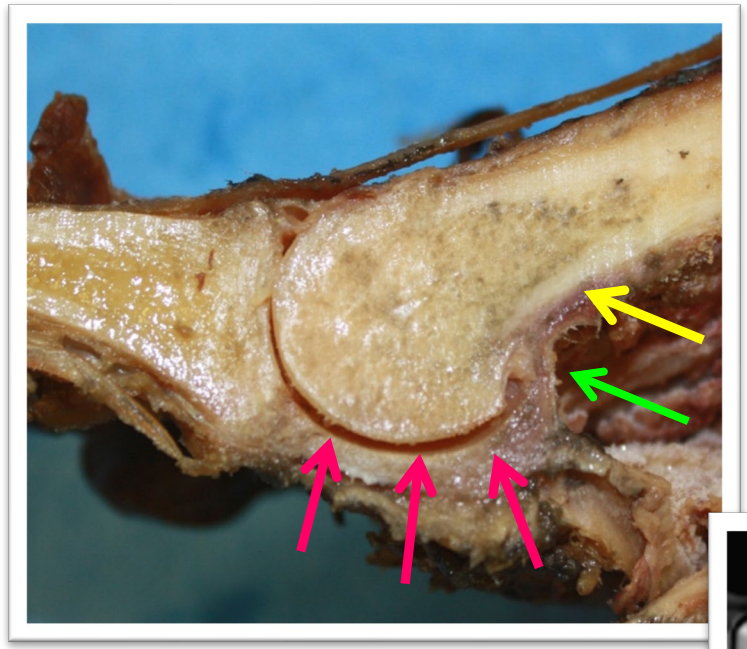


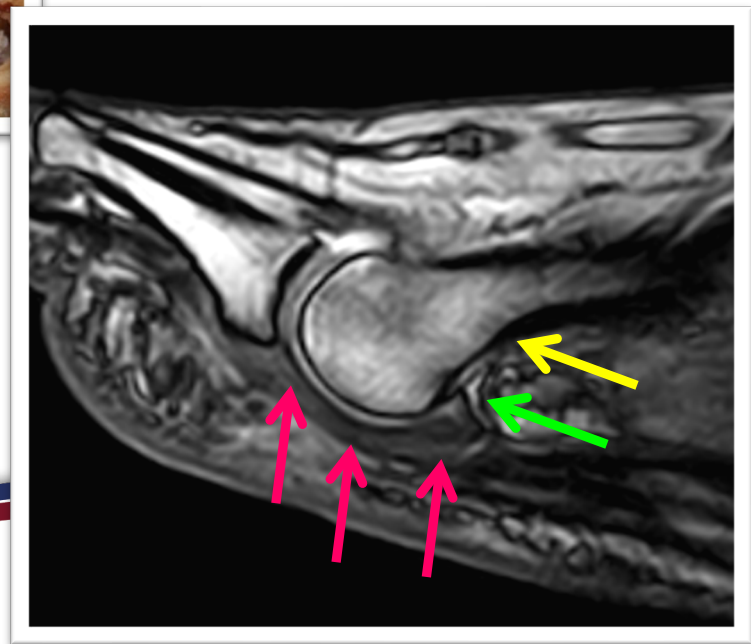
Deland, FAI, 1995.

Plantar plate attachments

- Distal attachment
  - One or two bundles
  - Firm
- Proximal attachment
  - Continuous with synovium of the MTPJ
  - Blends with peroisteum
  - Proximal to flare of metatarsal head

  - Loose, mobile attachment

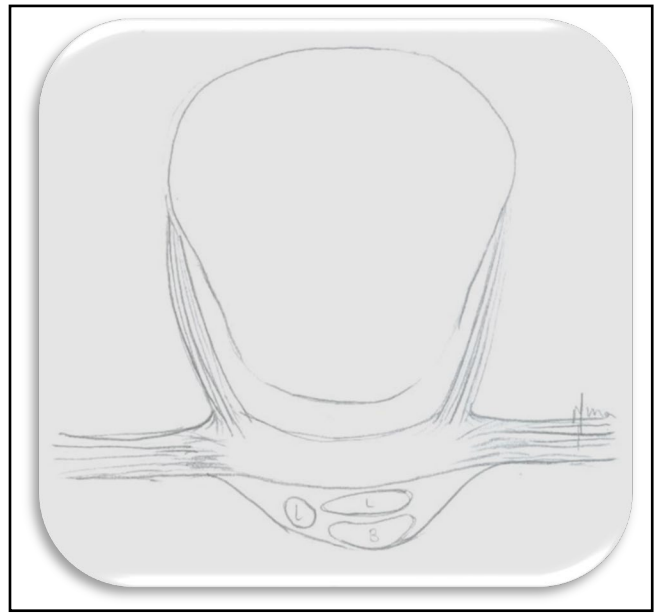




Johnston, FAI, 1994.

Transverse Intermetatarsal Ligament

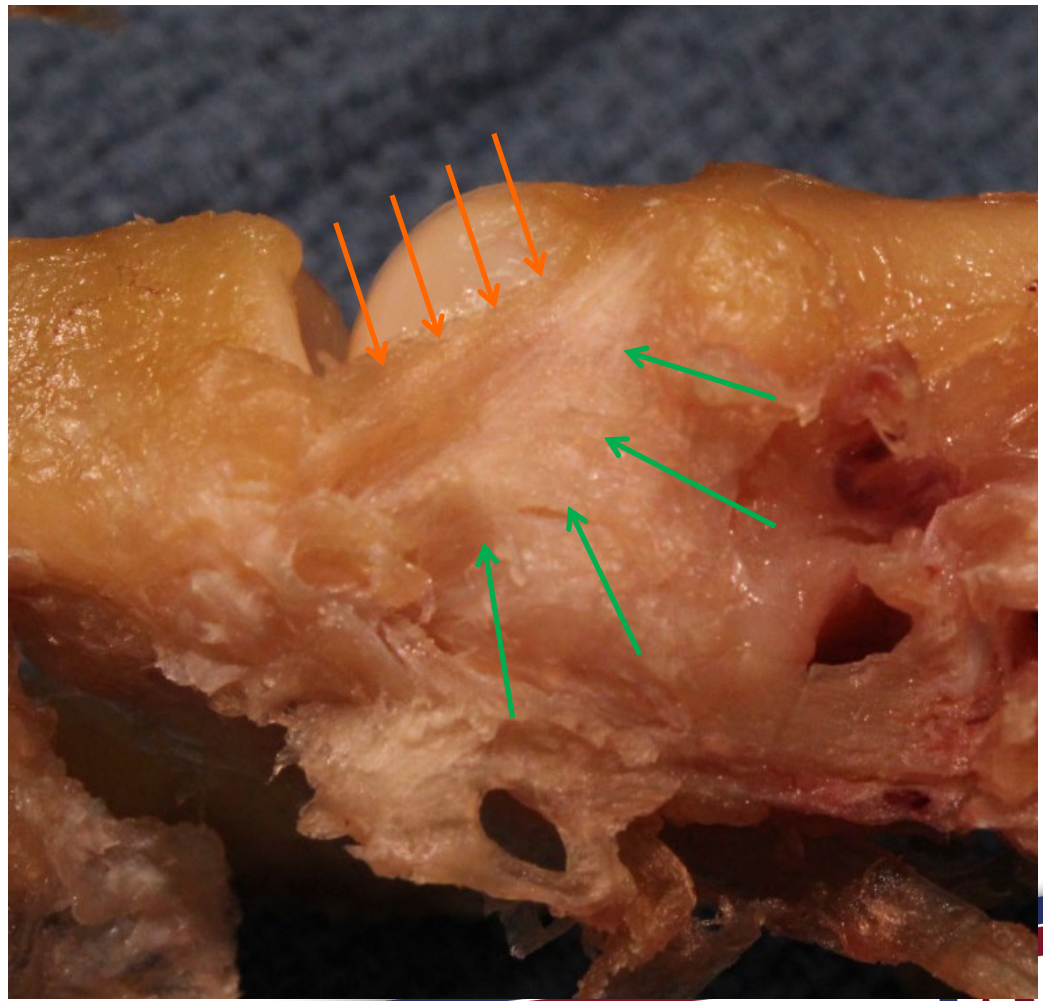
- No attachments to the metatarsal heads
- Plantar 1/3rd of the plantar plate
- Medial and lateral
- Transverse ‘tie-bar’ to control splaying of the forefoot



Deland, 1995, Johnston, 1994, Sarrafian, 1992, Stainsby 1997

The Collateral Ligament Complex

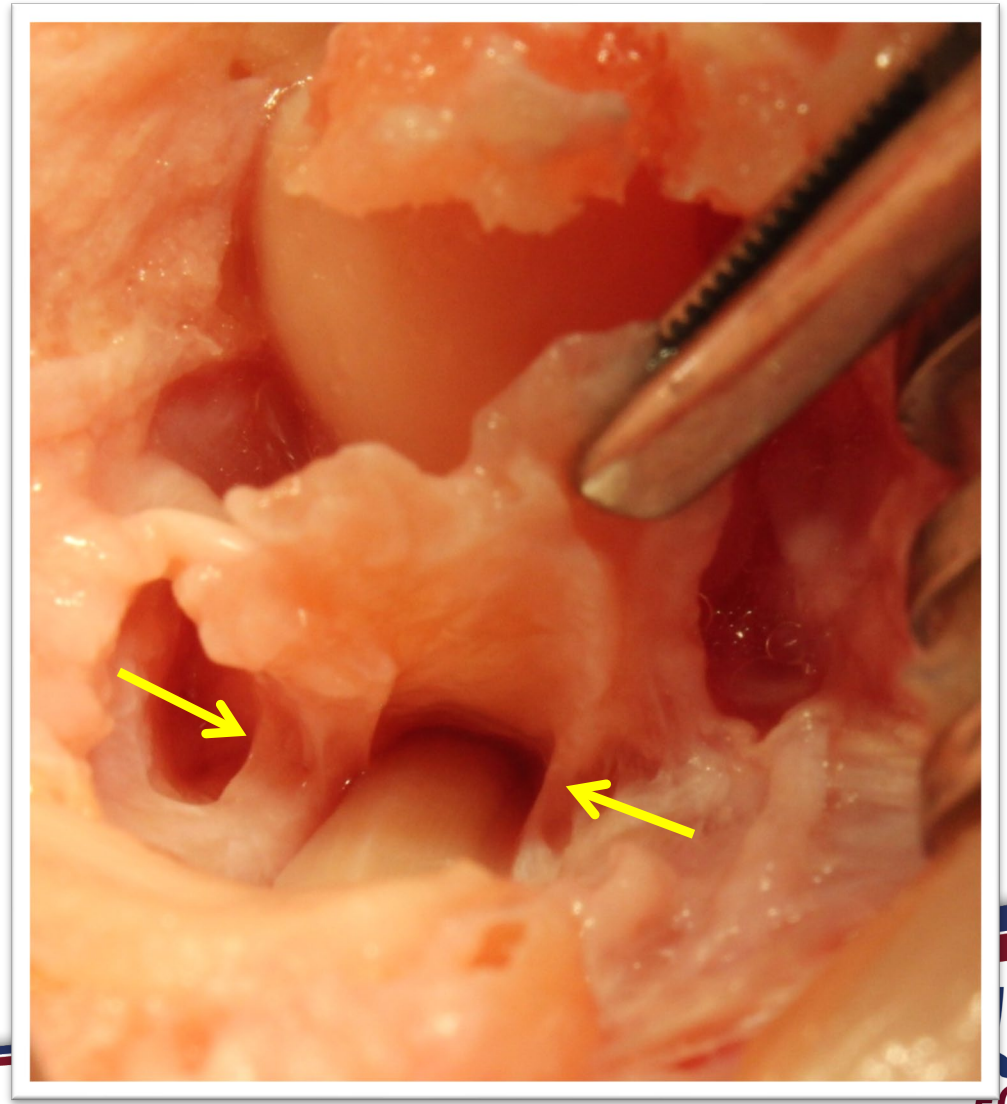
- Proper collateral ligament
  - Metatarsophalangeal collateral ligament
  - Anterior/superior portion of the tubercle of the metatarsal head
  - Insertion on the proximal phalanx is over a 2-3mm area.
- Accessory collateral ligament
  - Proximal, inferior portion of the tubercle on the metatarsal head
  - Plantar, slightly distal course
  - Insertion on the lateral portion of the plantar plate
  - The average length of the insertion onto the plantar plate is 10 mm.



Deland, 1995, Johnston, 1994, Sarrafian, 1992, Stainsby 1997

Plantar Fascia

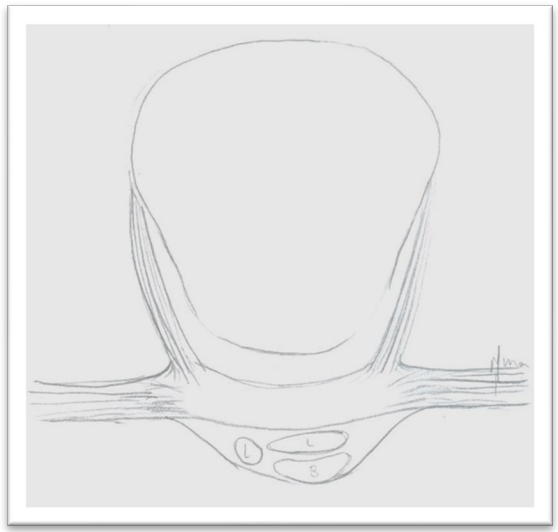
- Plantar fascia
  - Distally at the level of the metatarsal heads
  - Superficial and deep slips for each toe
  - Deep slips on medial and lateral sides of the flexor tendons
  - Insert on medial and lateral aspects of the plantar plate
- Flexor tendons
  - Groove on plantar surface
  - Fibrous sheath medially and laterally



Deland, 1995, Johnston, 1994, Sarrafian, 1992, Stainsby 1997

Instability at the MTP Joint

- Extensor substitution
  - Extensors have a mechanical advantage at the MTP joint
- Flexor stabilization
- Flexor substitution
  - Flexors are inherently weaker
- Plantar plate tear



Progressive Deformity

- Early signs are subtle
  - Pain
  - Edema
  - Positive drawer
  - Splaying of the 2nd and 3rd toes
  - Elevation of the 2nd toe?

Progressive Deformity

- Late deformity
  - Less pain
  - Minimal edema
  - Fixed deformities
  - Multiple joint involvement

In which patients should you suspect plantar plate pathology?

Patient History Parameters

Parameter	Incidence (%)	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Sudden onset	7%	7	100	100	8.9	NA
Gradual onset	93%	93	0	91.2	0	0
Pain >6 months	69%	73.4	28.6	93.2	7.4	1.104
Previous 1st ray surgery	18%	100	0	94.7	0	NA
Previous cortisone injection	21%	22.1	62.5	87.5	6.3	0.473
Neuroma?	90%	91.7	93.4	27.8	67	1.543

WEIL FOOT & ANKLE

Patient History Parameters

Parameter	Incidence (%)	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Sudden onset	**7%**	**7**	**100**	**100**	**8.9**	**NA**
Gradual onset	**93%**	**93**	**0**	**91.2**	**0**	**0**
Pain >6 months	69%	73.4	28.6	93.2	7.4	1.104
Previous 1st ray surgery	18%	100	0	94.7	0	NA
Previous cortisone injection	21%	22.1	62.5	87.5	6.3	0.473
Neuroma?	90%	91.7	93.4	27.8	67	1.543

WEIL FOOT & ANKLE

Patient History Parameters

Parameter	Incidence (%)	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Sudden onset	7%	7	100	100	8.9	NA
Gradual onset	93%	93	0	91.2	0	0
Pain >6 months	**69%**	**73.4**	**28.6**	**93.2**	**7.4**	**1.104**
Previous 1st ray surgery	18%	100	0	94.7	0	NA
Previous cortisone injection	21%	22.1	62.5	87.5	6.3	0.473
Neuroma?	90%	91.7	93.4	27.8	67	1.543

WEIL FOOT & ANKLE

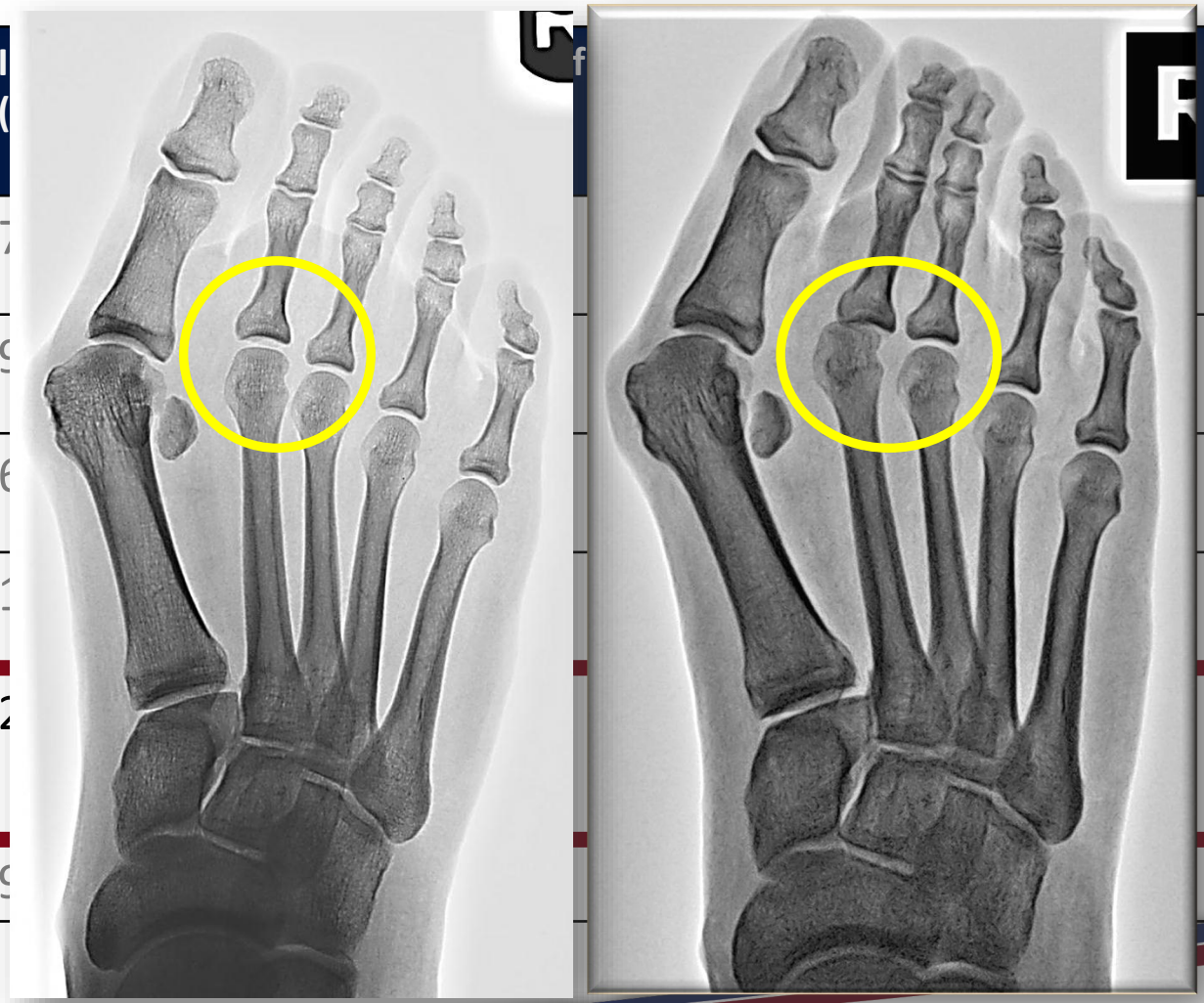
Patient History Parameters

Parameter	Incidence (%)	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Sudden onset	7%	7	100	100	8.9	NA
Gradual onset	93%	93	0	91.2	0	0
Pain >6 months	69%	73.4	28.6	93.2	7.4	1.104
Previous 1st ray surgery	18%	100	0	94.7	0	NA
Previous cortisone injection	**21%**	**22.1**	**62.5**	**87.5**	**6.3**	**0.473**
Neuroma?	90%	91.7	93.4	27.8	67	1.543

WEIL FOOT & ANKLE

Patient History Parameters

Parameter	I (	Odds Ratio
Sudden onset	7	NA
Gradual onset	9	0
Pain >6 months	6	1.104
Previous 1st ray surgery	1	NA
Previous cortisone injection	2	0.473
Neuroma?	9	1.543



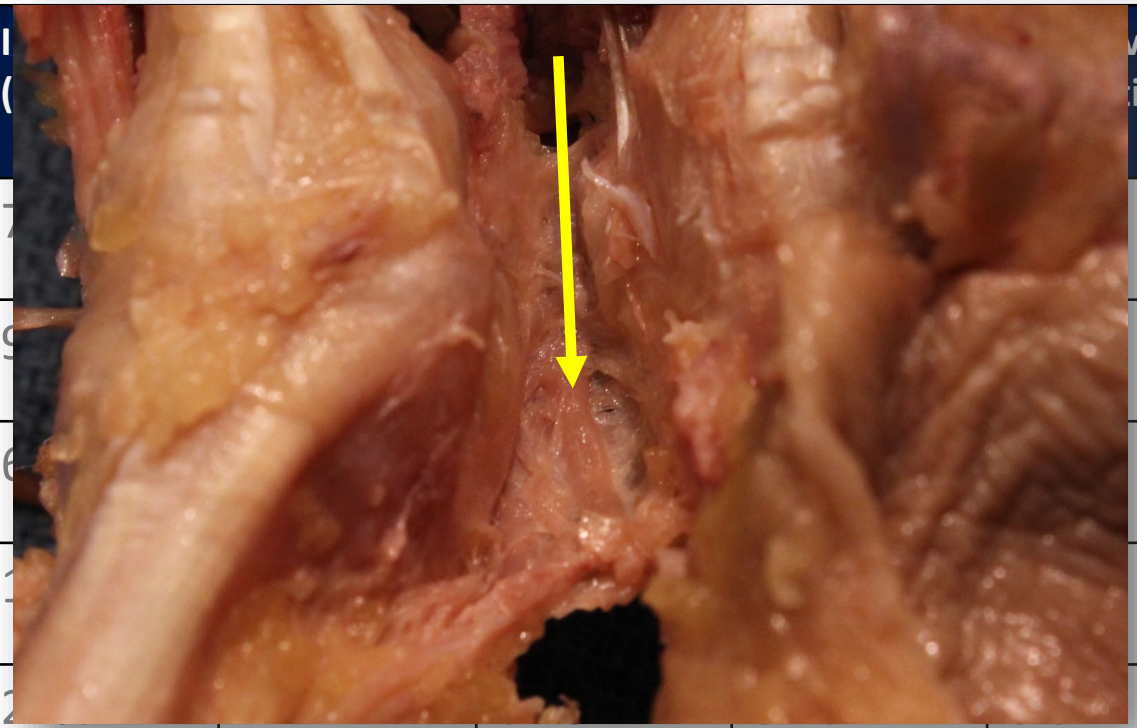
Patient History Parameters

Parameter	Incidence (%)	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Sudden onset	7%	7	100	100	8.9	NA
Gradual onset	93%	93	0	91.2	0	0
Pain >6 months	69%	73.4	28.6	93.2	7.4	1.104
Previous 1st ray surgery	18%	100	0	94.7	0	NA
Previous cortisone injection	21%	22.1	62.5	87.5	6.3	0.473
Neuroma?	**90%**	**91.7**	**93.4**	**27.8**	**67**	**1.543**

WEIL FOOT & ANKLE

Patient History Parameters

Parameter	I (	ve ive	Odds Ratio
Sudden onset	7		NA
Gradual onset	9		0
Pain >6 months	6		1.104
Previous 1st ray surgery	1		NA
Previous cortisone	2		0.473



If a patient has been diagnosed with a second interspace neuroma that has not responded to treatment, it may not be a neuroma.

WEIL FOOT & ANKLE

Patient Clinical Parameters

Parameter	Incidence	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Pain - 2nd metatarsal head	**98%**	**98**	**11.1**	**92.5**	**33.3**	**6.125**
Edema - 2nd metatarsal head	**92%**	**95.8**	**11.1**	**92.0**	**20.0**	**2.875**
Positive drawer sign	75%	80.6	99.8	92.6	10.0	1.389
Pain with 2nd MTP joint ROM	28%	31.5	77.8	93.3	10.3	1.607
Crossover toes	8%	8.0	88.9	88.9	8.0	0.696

WEIL FOOT & ANKLE

Patient Clinical Parameters

Parameter	Incidence	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Pain - 2nd metatarsal head	98%	98	11.1	92.5	33.3	6.125
Edema - 2nd metatarsal head	92%	95.8	11.1	92.0	20.0	2.875
Positive drawer sign	**75%**	**80.6**	**99.8**	**92.6**	**10.0**	**1.389**
Pain with 2nd MTP joint ROM	28%	31.5	77.8	93.3	10.3	1.607
Crossover toes	8%	8.0	88.9	88.9	8.0	0.696

WEIL FOOT & ANKLE

Patient Clinical Parameters

Parameter	Incidence	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Pain - 2nd metatarsal head	98%	98	11.1	92.5	33.3	6.125
Edema - 2nd metatarsal head	92%	95.8	11.1	92.0	20.0	2.875
Positive drawer sign	75%	80.6	99.8	92.6	10.0	1.389

When pain, edema and a positive drawer sign are combined, this will identify 95% of plantar plate tears.

WEIL FOOT & ANKLE

Drawer Sign

NEGATIVE

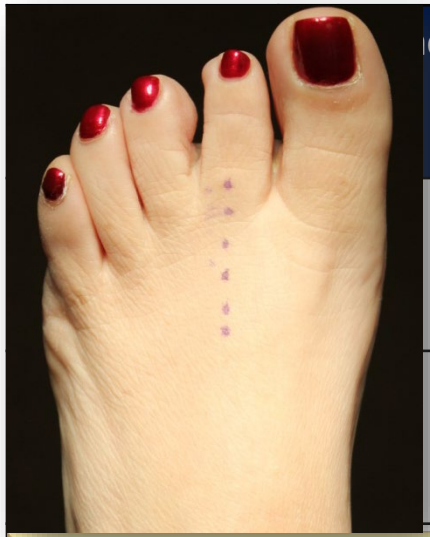
POSITIVE

Patient Clinical Parameters

Parameter	Incidence	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Odds Ratio
Pain - 2nd metatarsal head	98%	98	11.1	92.5	33.3	6.125
Edema - 2nd metatarsal head	92%	95.8	11.1	92.0	20.0	2.875
Positive drawer sign	75%	80.6	99.8	92.6	10.0	1.389
Pain with 2nd MTP joint ROM	28%	31.5	77.8	93.3	10.3	1.607
Crossover toes	**8%**	**8.0**	**88.9**	**88.9**	**8.0**	**0.696**

WEIL FOOT & ANKLE

Patient Clinical Parameters



92% of plantar plate tears were found in feet <u>without</u> crossover toes.

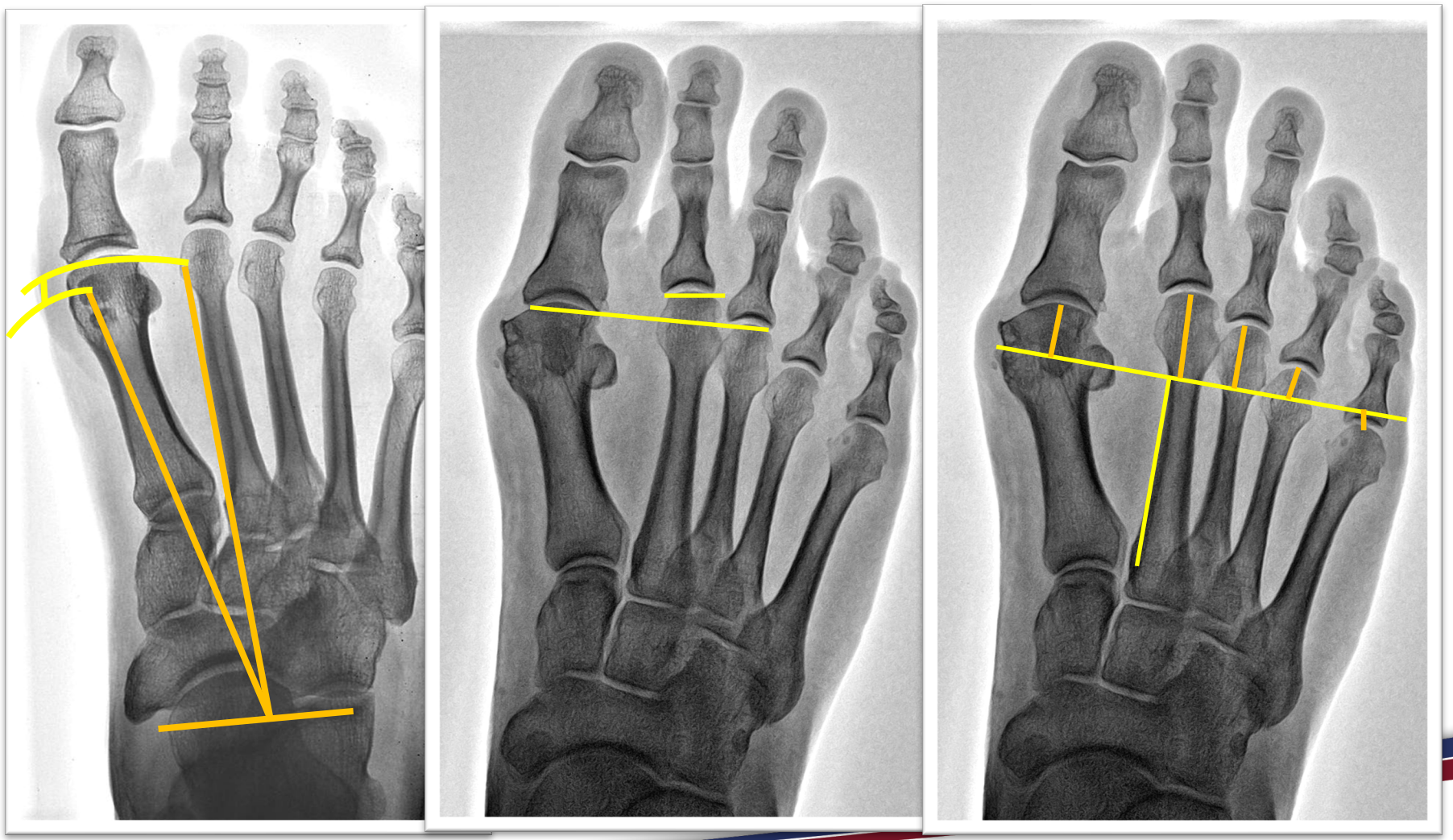
Crossover toes	8%	8.0	88.9	88.9	8.0	0.696

WEIL FOOT & ANKLE

What will be seen on radiographs?

WEIL FOOT & ANKLE

Welcome to the Metatarsal Parabola



WEIL FOOT & ANKLE

The Originating Factors

Parameters	Incidence	Sensitivity	Specificity	PPV	NPV	Odds Ratio
First intermetatarsal angle >12^0	47.1%	51.5%	66.7%	94.3%	11.3%	2.127
Metatarsus adductus angle >15^0	70.7%	77.3%	22.2%	91.5%	8.3%	0.974
Hardy & Clapham +/- 2 mm	50.0%	54.4%	50.0%	92.5%	8.9%	1.195
2nd metatarsal protrusion distance >2mm	**90.2%**	**97.9%**	**0%**	**92.0%**	**0%**	**0**
Maestro – 1st Metatarsal <10 mm	36.2%	39.4%	62.5%	92.5%	8.1%	1.081
Maestro – 2nd Metatarsal >13 mm	65.3%	71.0%	50.0%	94.3%	12.9%	2.444
Maestro – 3rd Metatarsal <9 mm	48.0%	52.1%	50.0%	92.5%	8.2%	1.089
First metatarsal declination >20^0	82.5%	90.4%	11.1%	91.4%	10%	1.181
MPE >8mm	17.8%	19.5%	75.0%	88.9%	8.3%	0.727
Second metatarsal declination >20^0	87.3%	95.7%	0%	90.8%	0%	0

- An odds ratio >1 = more likely to be diagnosed with plantar plate tear.
- An odds ratio <1 = less likely to be diagnosed with plantar plate tear.

WEIL™ FOOT & ANKLE

The Originating Factors

Parameters	Incidence	Sensitivity	Specificity	PPV	NPV	Odds Ratio
First intermetatarsal angle >12^0	47.1%	51.5%	66.7%	94.3%	11.3%	2.127
Metatarsus adductus angle >15^0	70.7%	77.3%	22.2%	91.5%	8.3%	0.974
Hardy & Clapham +/- 2 mm	50.0%	54.4%	50.0%	92.5%	8.9%	1.195
2nd metatarsal protrusion distance >2mm	**90.2%**	**97.9%**	**0%**	**92.0%**	**0%**	**0**
Maestro – 1st Metatarsal <10 mm	36.2%	39.4%	62.5%	92.5%	8.1%	1.081
Maestro – 2nd Metatarsal >13 mm	65.3%	71.0%	50.0%	94.3%	12.9%	2.444
Maestro – 3rd Metatarsal <9 mm	48.0%	52.1%	50.0%	92.5%	8.2%	1.089
First metatarsal declination >20^0	82.5%	90.4%	11.1%	91.4%	10%	1.181
MPE >8mm	17.8%	19.5%	75.0%	88.9%	8.3%	0.727
Second metatarsal declination >20^0	87.3%	95.7%	0%	90.8%	0%	0

- An odds ratio >1 = more likely to be diagnosed with plantar plate tear.
- An odds ratio <1 = less likely to be diagnosed with plantar plate tear.

WEIL FOOT & ANKLE

The Originating Factors

Parameters	Incidence	Sensitivity	Specificity
First intermetatarsal angle >12^0	47.1%	51.5%	66.7%
Metatarsus adductus angle >15^0	70.7%	77.3%	22.2%
Hardy & Clapham +/- 2 mm	50.0%	54.4%	50.0%
2^{nd} metatarsal protrusion distance >2mm	**90.2%**	**97.9%**	**0%**
Maestro – 1^{st} Metatarsal <10 mm	36.2%	39.4%	62.5%
Maestro – 2^{nd} Metatarsal >13 mm	65.3%	71.0%	50.0%
Maestro – 3^{rd} Metatarsal <9 mm	48.0%	52.1%	50.0%
First metatarsal declination >20^0	82.5%	90.4%	11.1%
MPE >8mm	17.8%	19.5%	75.0%
Second metatarsal declination >20^0	87.3%	95.7%	0%

- An odds ratio >1 = more likely to be diagnosed with plantar plate tear.
- An odds ratio <1 = less likely to be diagnosed with plantar plate tear.

The Resultant Factors

Parameters	Incidence	Sensitivity	Specificity	PPV	NPV	Odds Ratio
Lateral deviation of the 2nd toe	45.2%	49.5%	33.3%	88.9%	5.8%	0.489
Medial deviation of the 2nd toe	46.2%	50.5%	66.7%	94.2%	11.1%	2.041
Presence of splaying (2nd and 3rd digits)	59.4%	64.9%	77.8%	96.9%	17.1%	6.485
Transverse plane splay >5^0	55.7%	60.8%	77.8%	96.7%	15.6%	5.434
Second metatarsal-phalangeal angle >12^0	17.0%	18.6%	100%	100%	10.5%	n/a

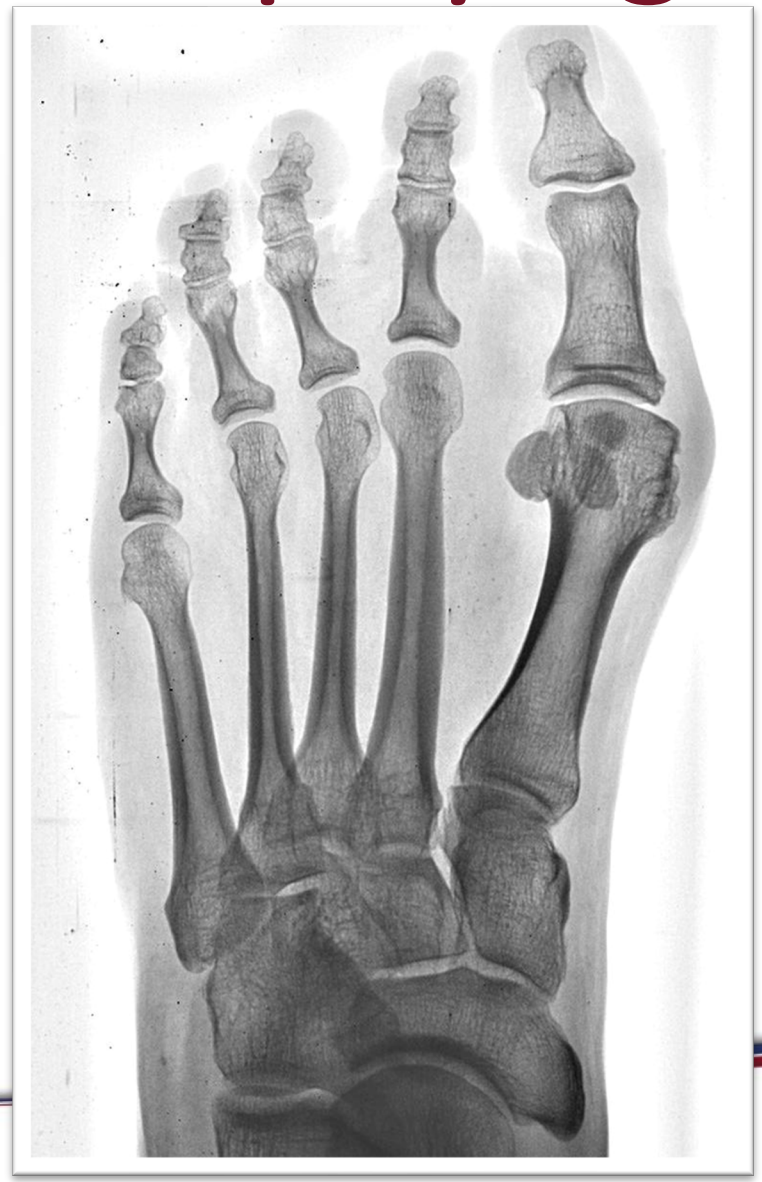
WEIL™ FOOT & ANKLE

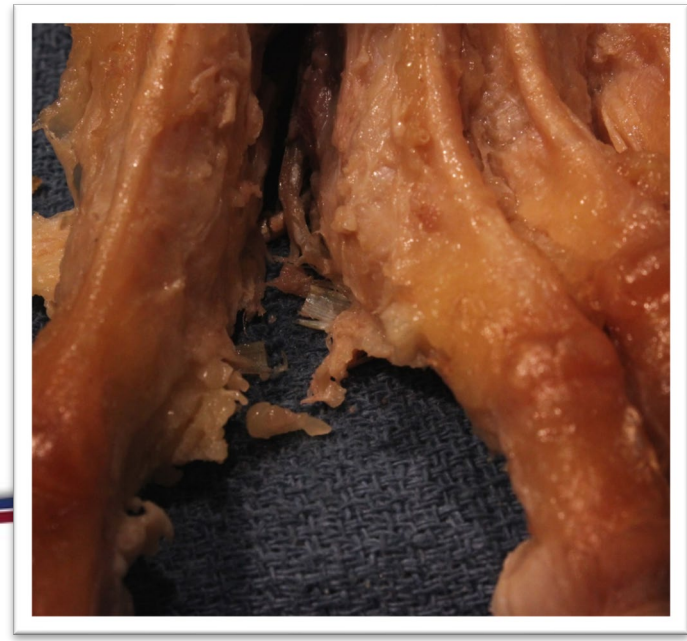
The Resultant Factors

Parameters	Incidence	Sensitivity	Specificity	PPV	NPV	Odds Ratio
Lateral deviation of the 2nd toe	45.2%	49.5%	33.3%	88.9%	5.8%	0.489
Medial deviation of the 2nd toe	46.2%	50.5%	66.7%	94.2%	11.1%	2.041
Presence of splaying (2nd and 3rd digits)	**59.4%**	**64.9%**	**77.8%**	**96.9%**	**17.1%**	**6.485**
Transverse plane splay $>5^0$	55.7%	60.8%	77.8%	96.7%	15.6%	5.434
Second metatarsal-phalangeal angle $>12^0$	17.0%	18.6%	100%	100%	10.5%	n/a

WEIL FOOT & ANKLE

Results – Toe Splaying





What about the other side?

Exam Parameter	Pathologic Side	Non – Pathologic Side	Difference
Hardy & Clapham's Method	-0.7 mm ± 3.23 mm (Range -10 – 10 mm)	-0.9 ± 2.9 mm (Range -9 mm – 5 mm)	0.2 mm
Coughlin's Method	**4.5 mm ± 1.2 mm (Range 2 – 7 mm)**	**3.7 ± 2.1 mm (Range -4 – 7 mm)**	**0.8 mm**
Maestro 1st Metatarsal	9.8 ± 2.5 mm (Range 5 – 15 mm)	9.8 ± 2.1 mm (Range 5 – 15 mm)	0 mm
Maestro 2nd Metatarsal	**13.8 ± 3.3 mm (Range 6 – 21 mm)**	**13.3 + 3.3 mm (Range 6 – 12 mm)**	**0.5 mm**
Maestro 3rd Metatarsal	9.1 ± 3.1 mm (Range 3 – 20 mm)	9.1 ± 3.1 mm (Range 3 – 20 mm)	0 mm

WEIL FOOT & ANKLE INSTITUTE

Metatarsal Length

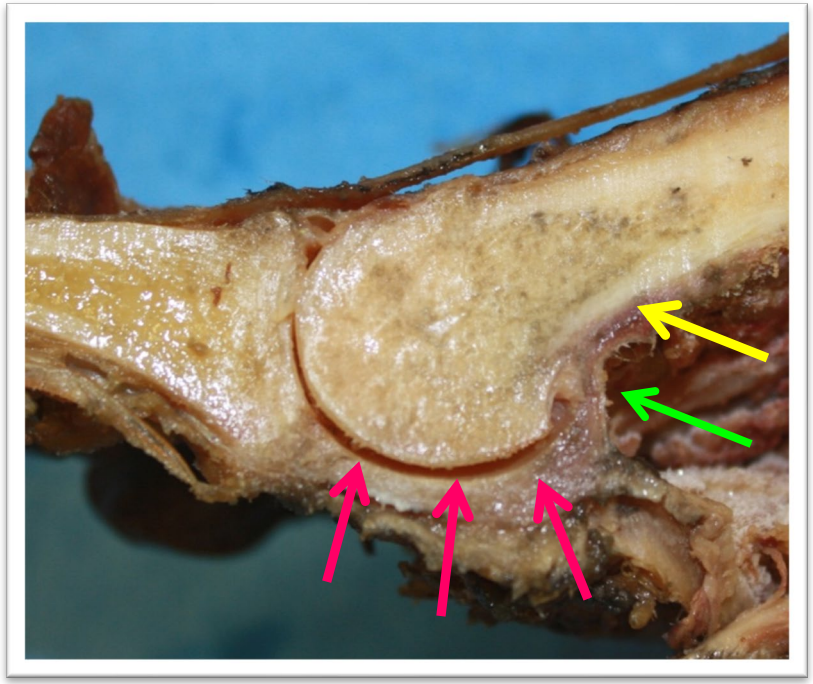
- Metatarsal parabola evaluation is critical
  - Underlying osseous deformity
  - Soft tissue imbalance

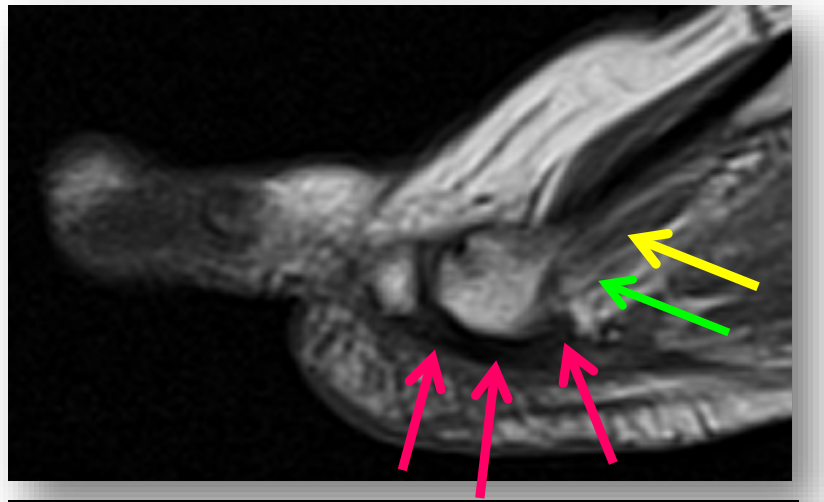
WEIL FOOT & ANKLE

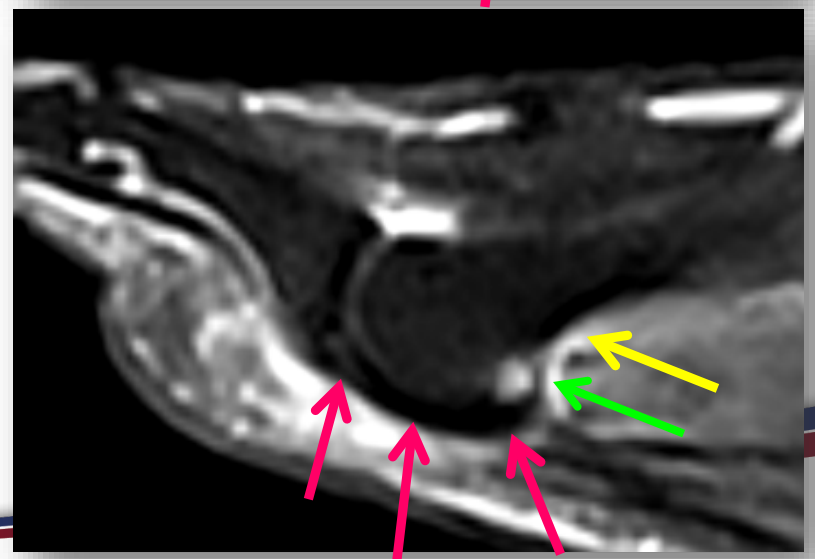
Advanced Imaging

You CAN see the plantar plate on advanced imaging studies!

Advanced Imaging

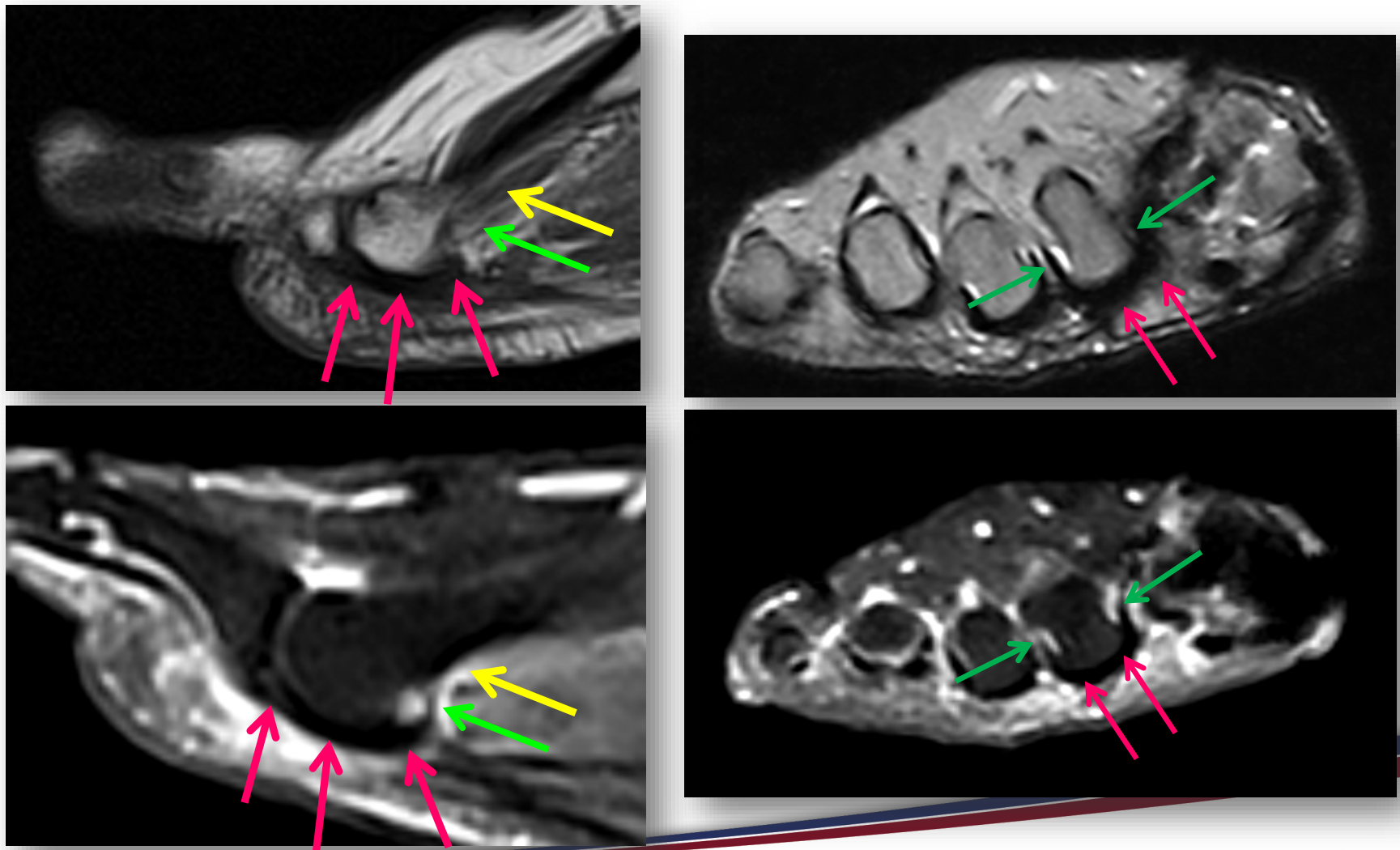




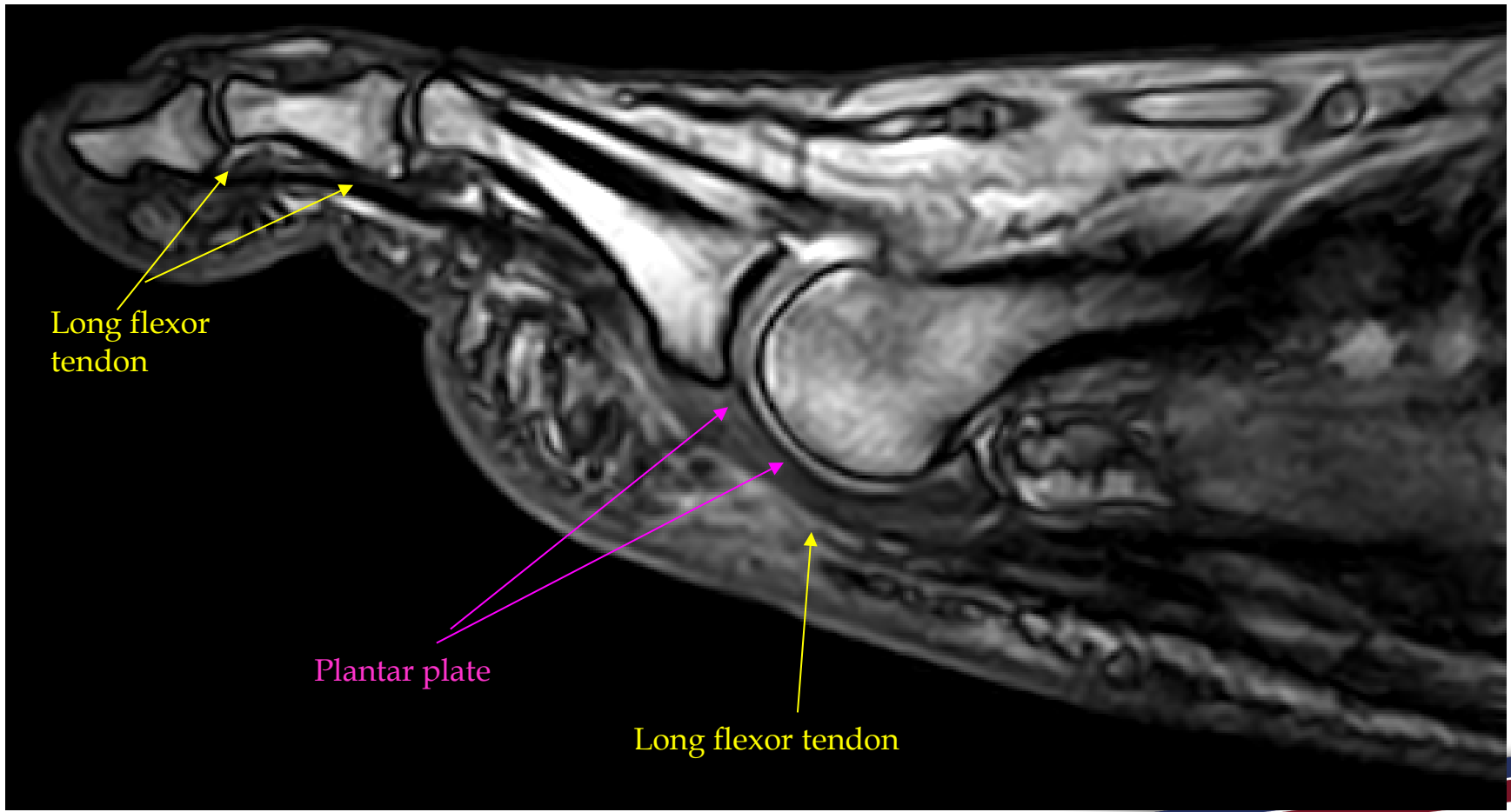


WEIL FOOT & ANKLE

Advanced Imaging



3D SHARC



WEIL FOOT & ANKLE

MRI Protocol

Sung W, et al. *Diagnosis of plantar plate injury by magnetic resonance imaging with reference to intra-operative findings.* **J Foot Ankle Surg**. 2012 Sept-Oct; 51(5): 570-574.

Non-Surgical Correction

What are the options?

Do they work?

WEIL FOOT & ANKLE

Shoes

- Decrease barefoot walking
- Decrease higher heels
- Wide enough to accommodate the forefoot

- Stiff bottom
- Soft upper

Orthotics

- What is the 1st MTPJ ROM?
- What is the current gait pattern?

- Metatarsal cookie
- 2nd met head cut out
- Multiple met head cut outs?

- Shock absorption of the device

WEIL FOOT & ANKLE

Bracing

- Primarily night time
- May not be tolerated

Taping/Straping

- Possible adjunct during the day
  - Beware cutting off the circulation to the toe with spika taping

- Kinesiotape?

Injections

- Cortisone
  - Not indicated
  - May make the problem worse
  - Documented to cause dislocations
- Biologic
  - May have a role for partial thickness tears
  - May cause dislocation

WEIL FOOT & ANKLE

Physical Therapy

- 1st MTPJ/1st ray function
- Lesser MTPJ function
- Intrinsic muscle strengthening
- Ankle joint contracture/equinus
- Gait stabilization/normalization
- Adjunctive modalities (ASTYM, graston, e-stim, laser, etc)

Intrinsic Muscle Strengthening

WEIL FOOT & ANKLE

Intrinsic Muscle Strengthening

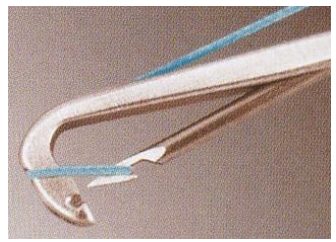
Surgical Correction

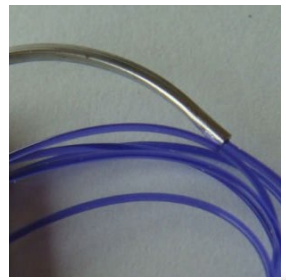
Currently Described Techniques

WEIL FOOT & ANKLE

Currently Described Techniques

- Dorsal Approach
  - Mini scorpion
  - Viper
  - Hat trick
- Plantar Approach
  - Vest over pants
  - Other





WEIL FOOT & ANKLE

Dorsal Approach Repair

Anatomic plantar plate repair using the Weil metatarsal osteotomy approach.

Weil L Jr, Sung W, Weil LS Sr, Malinoski K.

Foot Ankle Spec. 2011 Jun;4(3):145-50.

WEIL FOOT & ANKLE

WEIL FOOT & ANKLE

CPR - Viper

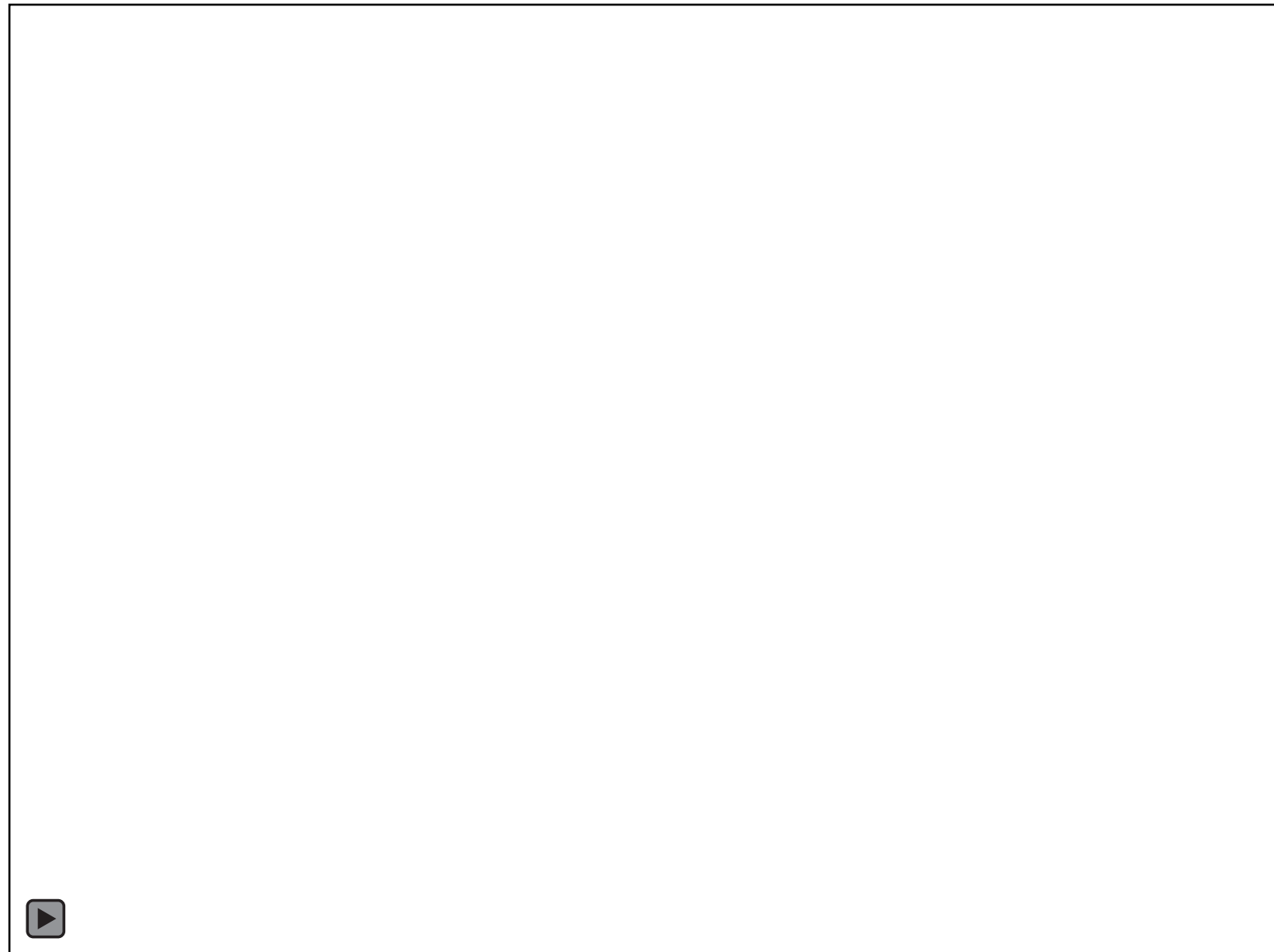
- Normal metatarsal length pattern
- Previous shortening osteotomy without plantar plate repair

- The metatarsal is NOT shortened in this scenario

Dorsal Approach Repair

Video Credit: Christopher Hyer, DPM

WEIL™ FOOT & ANKLE



WEIL FOOT & ANKLE

Comparing the Literature

	Prissel, et al.	Klein, et al.
Patient enrollment	131 patients (144 toes)	53 patients (53 toes)
Response rate	53.5%	90%
Length of follow-up	8.5 months	10 years
Well aligned toe	87.1%	87.5%
Recurrence	7.5%	5%
Revision	2.8%	35% (arthrofibrosis)
PROM	FFI significantly better	FAOS significantly better
VAS	2/10	1.5/10
Patient satisfaction	“Mixed rate of satisfaction”	78% of patients would do this again

EIL™ ANKLE

Comparing the Literature

	Prissel, et al.	Klein, et al.
Patient enrollment	131 patients (144 toes)	53 patients (53 toes)
Response rate	53.5%	90%
Length of follow-up	8.5 months	10 years
Well aligned toe	87.1%	87.5%
Recurrence	7.5%	5%
Revision	2.8%	35% (arthrofibrosis)
PROM	FFI significantly better	FAOS significantly better
VAS	2/10	1.5/10
Patient satisfaction	“Mixed rate of satisfaction”	78% of patients would do this again

EIL™ ANKLE

Comparing the Literature

	Prissel, et al.	Klein, et al.
Patient enrollment	131 patients (144 toes)	53 patients (53 toes)
Response rate	53.5%	90%
Length of follow-up	8.5 months	10 years
Well aligned toe	87.1%	87.5%
Recurrence	7.5%	5%
Revision	2.8%	35% (arthrofibrosis)
PROM	FFI significantly better	FAOS significantly better
VAS	2/10	1.5/10
Patient satisfaction	"Mixed rate of satisfaction"	78% of patients would do this again

Where is research still needed?

Where is research still needed?

Non-surgical care.

Physical therapy.

The role of peri menopausal hormones in msk health and post operative outcomes.

More surgical outcome studies that focus on the patient's perception of outcome rather than radiographic outcome.

WEIL™ FOOT & ANKLE

What can we conclude from all of this?

Conclusions

- Plantar plate repair is a common pathology that can affect patients physically and alter their quality of life.

- Surgical treatment options are available for these patients but more research is needed in the realm of non-surgical care.

References - Anatomy

- Bojsen-Moller F, Flagstad KE. 1976. Plantar aponeurosis and internal architecture of the ball of the foot. *Journal of anatomy* 121:599-611
- Coughlin MJ, Schutt SA, Hirose CB, Kennedy MJ, Grebing BR, et al. 2012. Metatarsophalangeal joint pathology in crossover second toe deformity: a cadaveric study. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society* 33:133-40
- Cruveilhier, J., G.S. Pattison, and W.H. Madden, *The anatomy of the human body*. The 1st American, from the last Paris ed1844, New York,: Harper & Brothers. xv, 907 p
- Deland JT, Sung IH. 2000. The medial crosssover toe: a cadaveric dissection. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society* 21:375-8
- Deland, J.T., et al., *Anatomy of the plantar plate and its attachments in the lesser metatarsal phalangeal joint.* Foot Ankle Int, 1995. **16**(8): p. 480-6.
- Johnston, R.B., 3rd, J. Smith, and T. Daniels, *The plantar plate of the lesser toes: an anatomical study in human cadavers.* Foot Ankle Int, 1994. **15**(5): p. 276-82.
- Mizel MS, Yodlowski ML. 1995. Disorders of the Lesser Metatarsophalangeal Joints. *The Journal of the American Academy of Orthopaedic Surgeons* 3:166-73
- Petersen, W.J., et al., *The arterial supply of the lesser metatarsal heads: a vascular injection study in human cadavers.* Foot Ankle Int, 2002. **23**(6): p. 491-5.
- Sarrafian, S.K. and L.K. Topouzian, *Anatomy and physiology of the extensor apparatus of the toes.* J Bone Joint Surg Am, 1969. **51**(4): p. 669-79.
- Stainsby GD. 1997. Pathological anatomy and dynamic effect of the displaced plantar plate and the importance of the integrity of the plantar plate-deep transverse metatarsal ligament tie-bar. *Annals of the Royal College of Surgeons of England* 79:58-68
- Thompson FM, Hamilton WG. 1987. Problems of the second metatarsophalangeal joint. *Orthopedics* 10:83-9

WEIL™ FOOT & ANKLE

References – Clinical Exam

- Coughlin MJ. 1987. Crossover second toe deformity. *Foot & ankle* 8:29-39
- Coughlin MJ. 1989. Subluxation and dislocation of the second metatarsophalangeal joint. *The Orthopedic clinics of North America* 20:535-51
- Coughlin MJ. 1993. Second metatarsophalangeal joint instability in the athlete. *Foot & ankle* 14:309-19
- Fortin PT, Myerson MS. 1995. Second metatarsophalangeal joint instability. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society* 16:306-13
- Kaz AJ, Coughlin MJ. 2007. Crossover second toe: demographics, etiology, and radiographic assessment. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society* 28:1223-37
- Klein EE, et al. *Clinical examination of plantar plate abnormality: a diagnostic perspective.* FAI (2013): 34(6): 800-804.
- Klein EE, et al. *Positive drawer test combined with radiographic deviation of the third metatarsophalangeal joint suggests high grade tear of the second metatarsophalangeal joint plantar plate.* Foot Ankle Spec 2014. Sept 18. Epub ahead of print.
- Mann RA, Mizel MS. 1985. Monarticular nontraumatic synovitis of the metatarsophalangeal joint: a new diagnosis? *Foot & ankle* 6:18-21
- Yu GV, Judge MS, Hudson JR, Seidelmann FE. 2002. Predislocation syndrome. Progressive subluxation/dislocation of the lesser metatarsophalangeal joint. *Journal of the American Podiatric Medical Association* 92:182-99

WEIL™ FOOT & ANKLE

References - Radiographs

- Coughlin MJ. 1987. Crossover second toe deformity. *Foot & ankle* 8:29-39
- Coughlin MJ. 1989. Subluxation and dislocation of the second metatarsophalangeal joint. *The Orthopedic clinics of North America* 20:535-51
- Coughlin MJ. 1993. Second metatarsophalangeal joint instability in the athlete. *Foot & ankle* 14:309-19
- Fortin PT, Myerson MS. 1995. Second metatarsophalangeal joint instability. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society* 16:306-13
- Kaz AJ, Coughlin MJ. 2007. Crossover second toe: demographics, etiology, and radiographic assessment. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society* 28:1223-37
- Klein EE, et al. *The underlying osseous deformity in plantar plate tears: a radiographic analysis.* Foot Ankle Spec 2013. 6(2): 108-118.
- Klein EE, et al. *Positive drawer test combined with radiographic deviation of the third metatarsophalangeal joint suggests high grade tear of the second metatarsophalangeal joint plantar plate.* Foot Ankle Spec 2014. Sept 18. Epub ahead of print.
- Yu GV, Judge MS, Hudson JR, Seidelmann FE. 2002. Predislocation syndrome. Progressive subluxation/dislocation of the lesser metatarsophalangeal joint. *Journal of the American Podiatric Medical Association* 92:182-99

WEIL™ FOOT & ANKLE

References – MRI/US

- Feuerstein CA, et al. *Static versus dynamic ultrasound for detection of plantar plate pathology.* Foot Ankle Spec 2014. 7(4): 259-65.
- Gregg, J., et al., *Sonographic and MRI evaluation of the plantar plate: A prospective study.* Eur Radiol, 2006. **16**(12): p. 2661-9.
- Gregg, J.M., et al., *Sonography of plantar plates in cadavers: correlation with MRI and histology.* AJR Am J Roentgenol, 2006. **186**(4): p. 948-55.
- Klein EE et al. *Musculoskeletal ultrasound for preoperative imaging of the plantar plate: a prospective analysis.* Foot Ankle Spec 2013. 6(3): 196-200.
- Klein EE, et al. *Magnetic resonance imaging versus musculoskeletal ultrasound for localization and identification of plantar plate tears.* Foot ankle spec 2012. 5(6): 570-574.
- Sung, W., et al., *Diagnosis of Plantar Plate Injury by Magnetic Resonance Imaging with Reference to Intraoperative Findings.* J Foot Ankle Surg, 2012.
- Yao, L., et al., *Magnetic resonance imaging of plantar plate rupture.* Foot Ankle Int, 1996. **17**(1): p. 33-6.

References – Surgical Technique

- Coughlin, M.J., D.S. Baumfeld, and C. Nery, *Second MTP joint instability: grading of the deformity and description of surgical repair of capsular insufficiency.* Phys Sportsmed, 2011. **39**(3): p. 132-41.
-
- Bhatia, D., et al., *Anatomical restraints to dislocation of the second metatarsophalangeal joint and assessment of a repair technique.* J Bone Joint Surg Am, 1994. **76**(9): p. 1371-5.
- Bouche, R.T. and E.J. Heit, *Combined plantar plate and hammertoe repair with flexor digitorum longus tendon transfer for chronic, severe sagittal plane instability of the lesser metatarsophalangeal joints: preliminary observations.* J Foot Ankle Surg, 2008. **47**(2): p. 125-37.
- Thompson, F.M. and J.T. Deland, *Flexor tendon transfer for metatarsophalangeal instability of the second toe.* Foot Ankle, 1993. **14**(7): p. 385-8.
- Weil L, Jr., Sung W, Weil LS, Sr., Malinoski K. 2011. Anatomic plantar plate repair using the Weil metatarsal osteotomy approach. *Foot & ankle specialist* 4:145-50
-

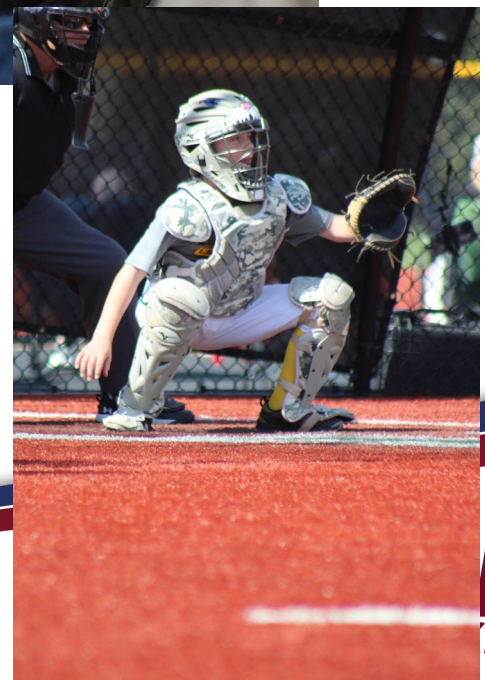
WEIL FOOT & ANKLE

Thank you!

Erin E. Klein, DPM, MS, FACFAS, DABPM

eek@weil4feet.com

www.WEIL4FEET.com

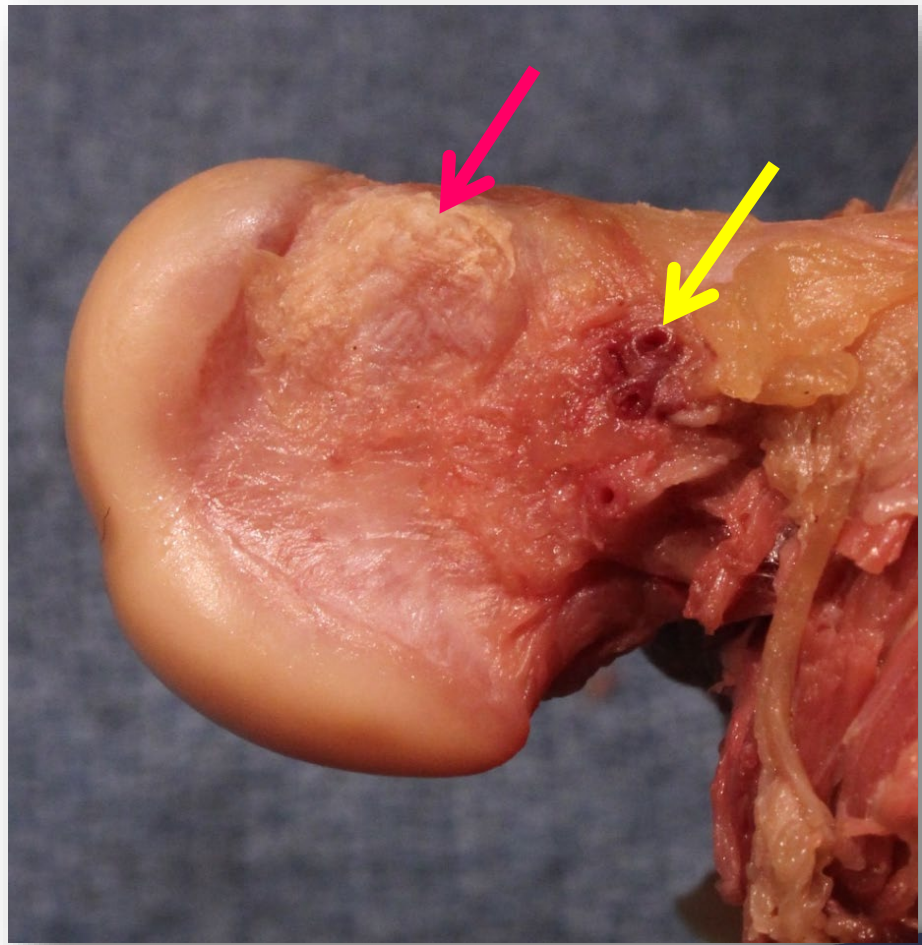


Commonly Asked Questions

Why do you dissect the collaterals from the phalangeal base rather than the metatarsal head?

WEIL FOOT & ANKLE

Metatarsal Head Blood Supply

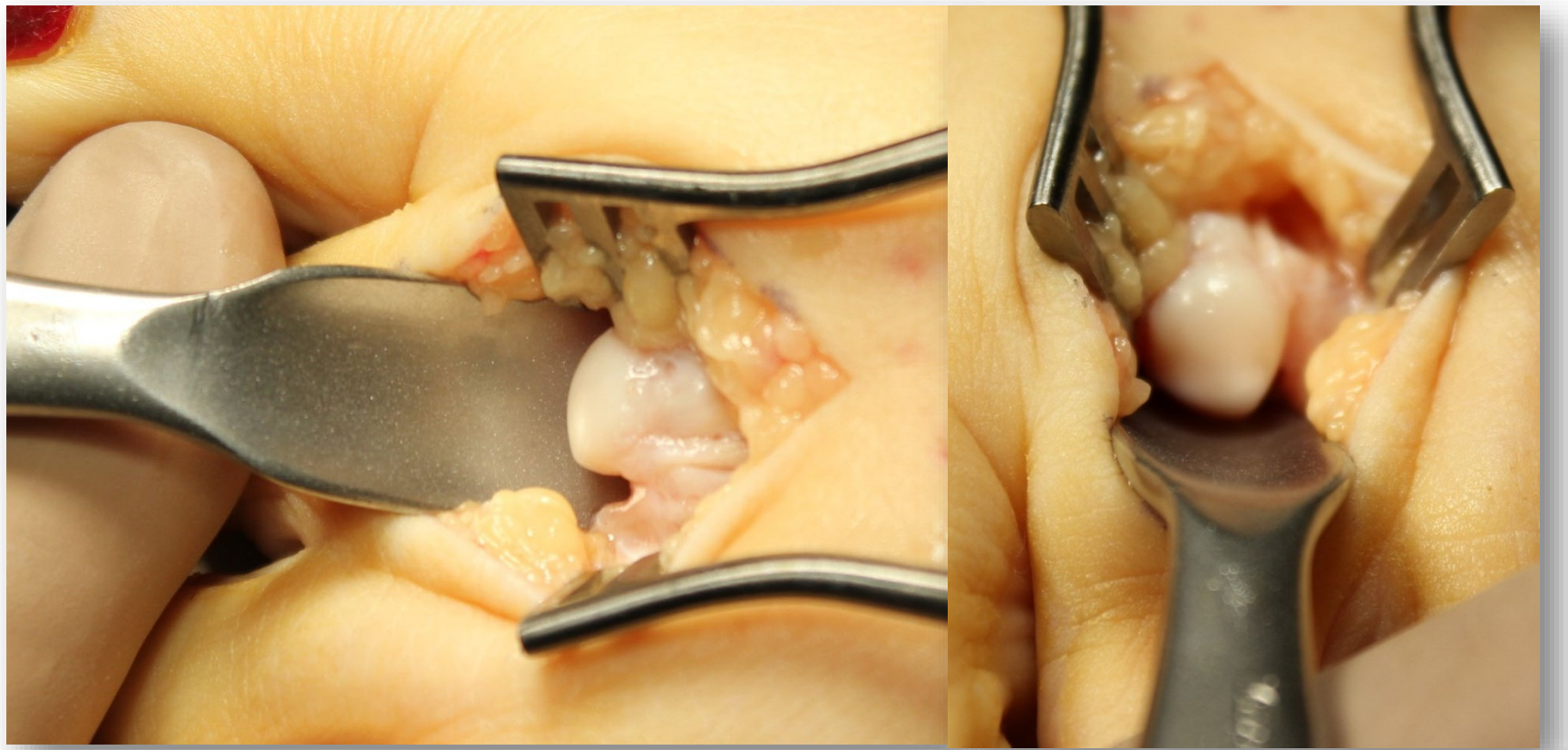


Commonly Asked Questions

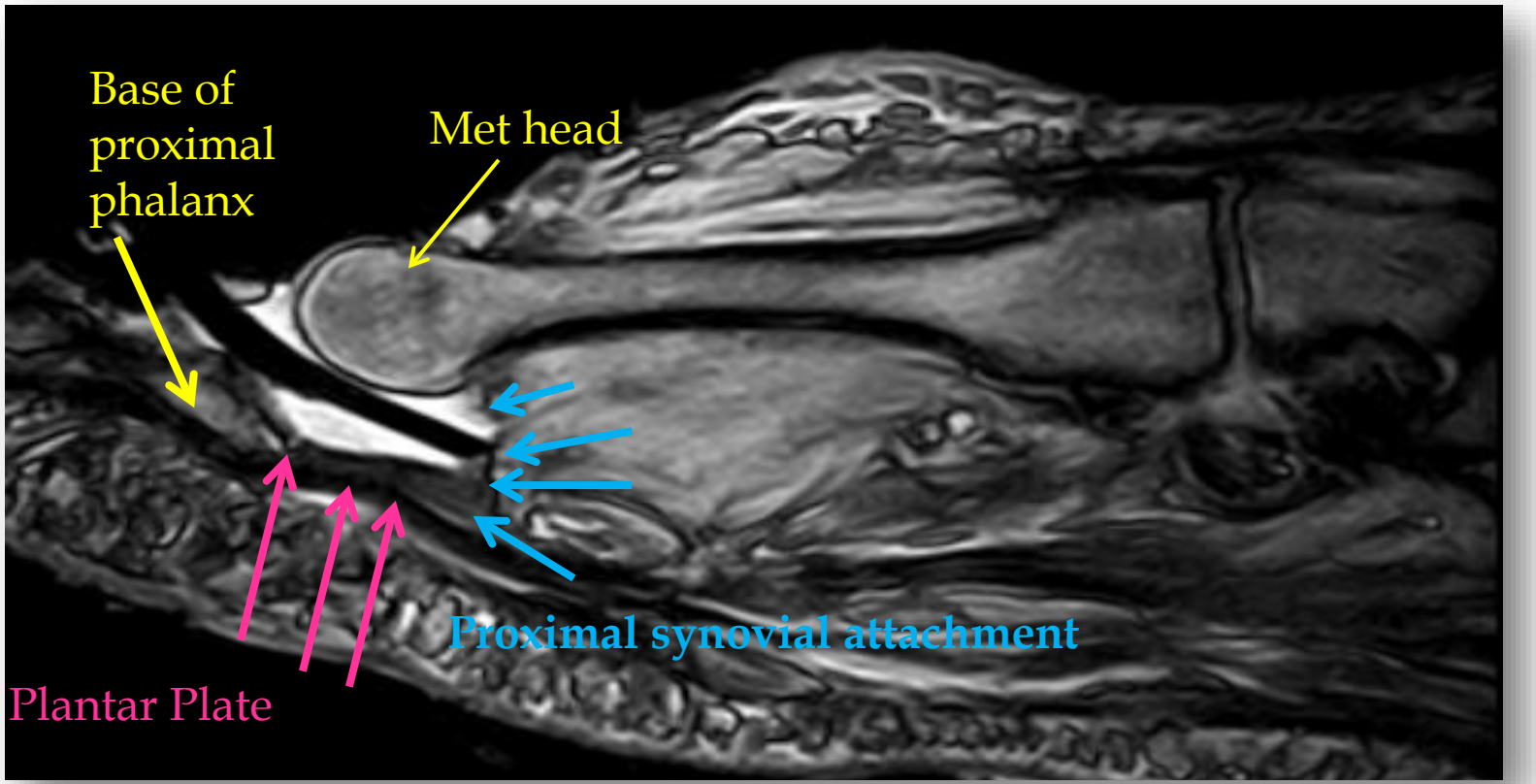
What is the McGlamry actually doing?

WEIL FOOT & ANKLE

McGlamry Elevator



McGlamry Elevator



Commonly Asked Questions

What is your post operative course/protocol?

WEIL FOOT & ANKLE

Post Op Protocol

- POD #7 - 10
  - PWB in a surgical shoe
- POD#10
  - Gym shoe
  - Physical therapy
  - Night time bracing

Stabilization Strap

WEIL FOOT & ANKLE

1 Year Post Op

WEIL FOOT & ANKLE

1 Year Post Op - ROM

WEIL FOOT & ANKLE

1 Year Post Op – Drawer Sign

1 Year Post Op - Strength

WEIL FOOT & ANKLE

Do patients actually get better with this procedure?

YES!!!!!

Results

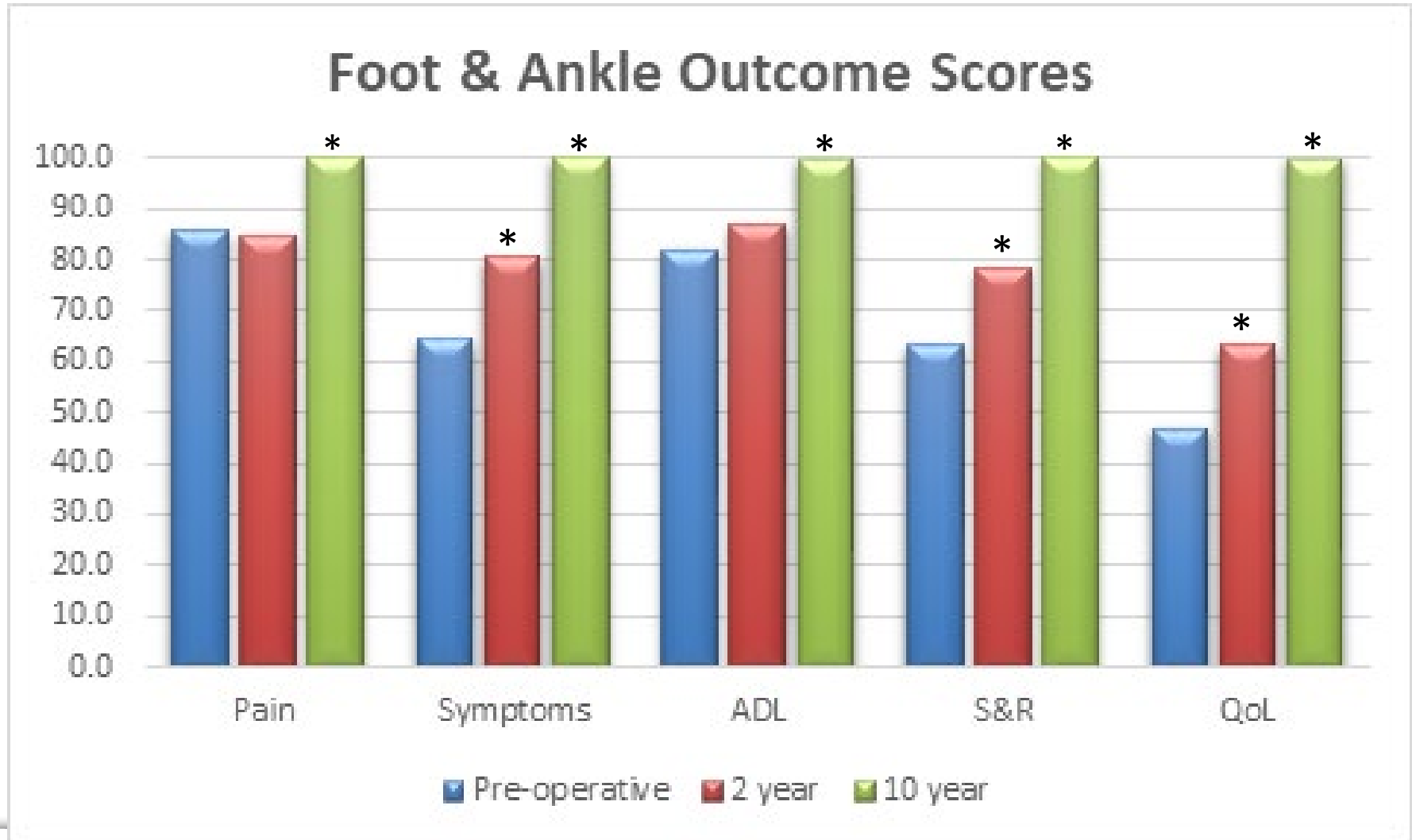
- 53 consecutive 2nd MTP joints
  - 50 women; 3 men
- Average: 58.2 ± 9.8 years of age

Surgical grading system	Description of tear	Frequency of occurrence in this patient population
Grade I	<50% transverse tear	13.2%
Grade II	>50% transverse tear	66.0%
Grade III	Vertical tear	18.9%
Grade IV	Complete tear	1.9%

Results

	VAS Pain	Edema Present	Positive Drawer Sign
Pre-operatively	6.5 ± 1.5	94%	97%
2 years post-operative	1.5 ± 0.5	15%	2.3%
10 years post-operative	0.75 ± 0.6	--	--

Results



WEIL FOOT & ANKLE