

Rehabilitation after forefoot surgery – what is new what is worthwhile ?

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ORTHO**PAEDIE**
<http://www.schuh-orthopaedie.at>

I have no potential conflicts
with
this presentation.





Immobilization

Adherence of synovial tissue and articular cartilage

Cartilage



Regional Bone Mineral Density



Desorganization of ligamentous microarchitecture

Ligament footprints



Akeson WH, Effect of Immobilisation on Joints, CORR 1987

Biomechanics First Ray - Gait



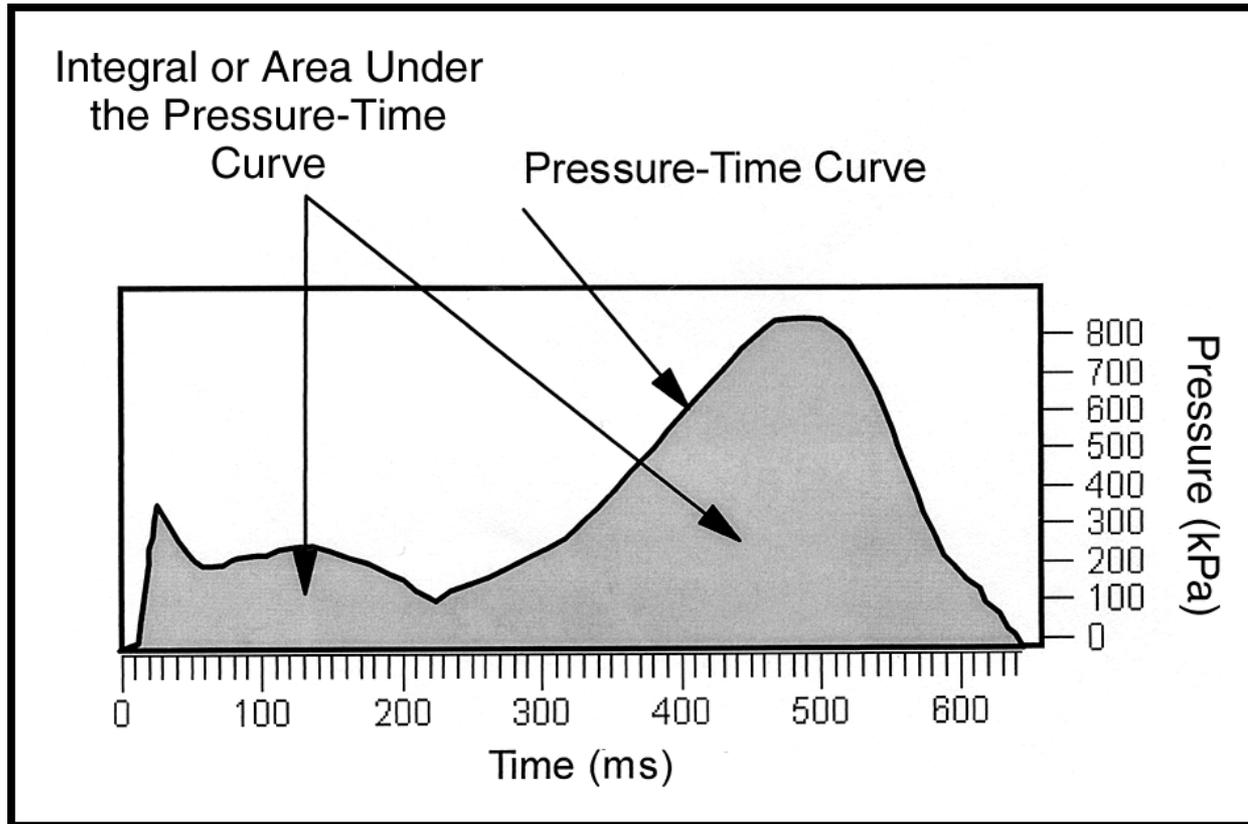
first ray most loaded
structure during stance
phase of gait

FHL and FHB transmit
52% of body weight

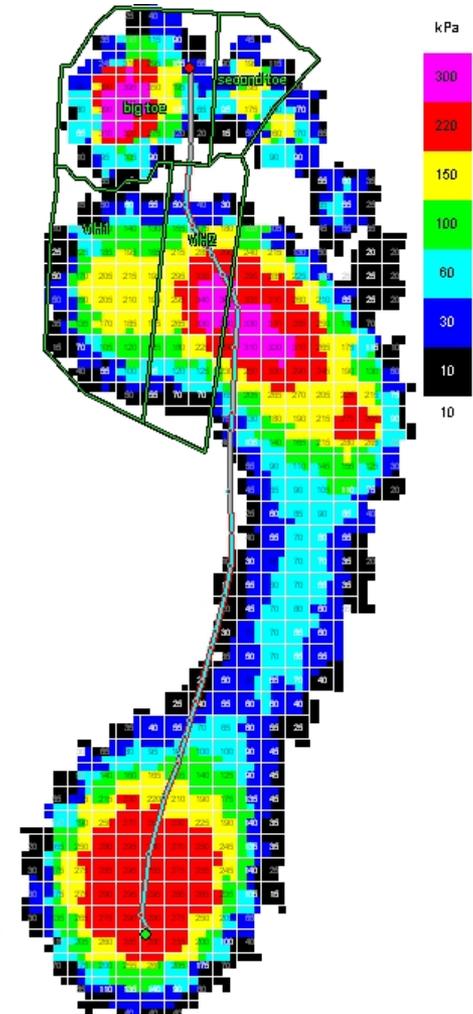
Jacob, H.A.C.: Forces acting in the forefoot during normal gait - an estimate. Clin Biomech 2001

Mann, R.A.: Function of toes in walking, jogging and running. Clin Ortho Rel Res 1979

Pedobarography



Orlin et al., Physical Therapy . Volume 80 .
www.novel.de



Normal pressure values and repeatability of the Emed[®] ST4 system

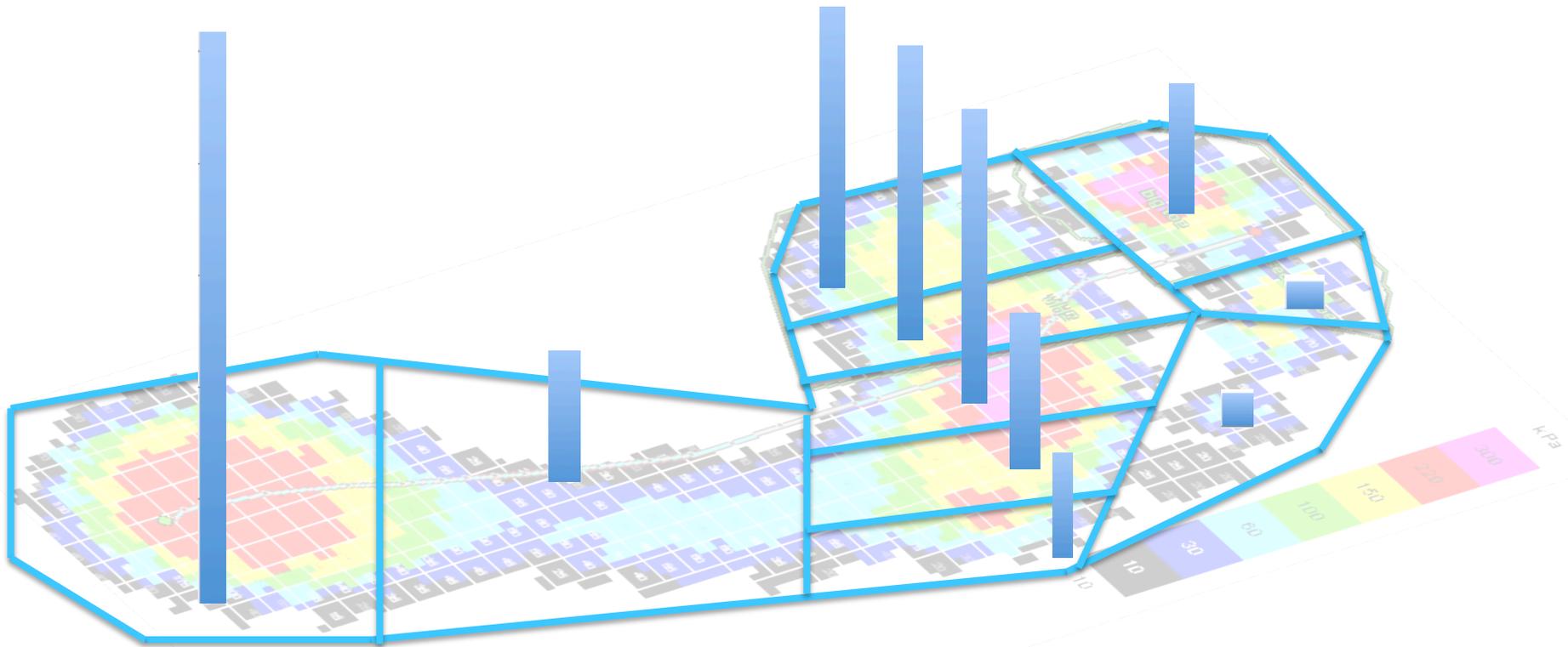
A.B. Putti, G.P. Arnold, L.A. Cochrane, R.J. Abboud*

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Dundee DD1 9SY, Scotland, UK*

Emed [®] masks	PP (kPa)		CA (cm ²)		CT (ms)		PTI (kPa s)		FTI (N s)		IPP (ms)	
	Mean (S.D.)	CR ^a	Mean (S.D.)	CR	Mean (S.D.)	CR	Mean (S.D.)	CR	Mean (S.D.)	CR	Mean (S.D.)	CR
Heel	313 (77)	3.6	34.5 (5.2)	0.8	393 (95)	2.5	73 (25)	3.4	105 (31)	3.3	99 (56)	13.6
Mid-foot	113 (37)	4.7	23.8 (9.8)	2.1	438 (98)	2.2	33 (15)	5.9	28 (23)	7.3	212 (82)	10.3
1 MT ^b head	277 (90)	7.7	13.6 (2.4)	1.6	562 (66)	1.7	87 (37)	7.1	52 (20)	5.4	531 (71)	1.9
2 MT head	361 (104)	2.9	10.5 (1.8)	2.0	576 (66)	1.4	107 (35)	3.1	54 (15)	2.7	563 (70)	1.7
3 MT head	330 (84)	3.6	11.5 (1.9)	1.5	589 (70)	1.3	104 (30)	3.6	57 (16)	4.9	551 (74)	1.3
4 MT head	233 (67)	4.5	9.5 (1.4)	1.7	577 (70)	1.3	80 (30)	4.3	35 (13)	5.9	504 (90)	1.9
5 MT head	151 (78)	9.9	5.9 (1.0)	2.7	528(77)	1.7	50 (30)	7.8	14 (7)	8.6	413 (120)	6.3
Hallux	321 (141)	6.2	10.4 (2.1)	1.5	478 (113)	3.5	81 (49)	8.4	26 (13)	7.3	559 (80)	1.8
Second toe	158 (73)	5.4	3.6 (1.1)	4.5	432 (100)	2.8	37 (24)	6.6	5 (3)	8.7	570 (71)	1.6
Third to fifth toes	111 (54)	9.9	7.3 (2.4)	4.8	457 (116)	4.6	29 (22)	12.7	6 (5)	15.4	575 (78)	2.3

A.B. Putti et al. / Gait & Posture 27 (2008) 501–505

Force time integral



Pathomechanics

Valgus force

Lateral Sesamoidal luxation

Pronation of hallux

Mann & Coughlin., CORR 1981

Jahss M., CORR 1981



Plantar Pressure Characteristics in Hallux Valgus Feet

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Received 5 December 2013; accepted 3 July 2014

Published online in Wiley Online Library (wileyonlinelibrary.com). DOI 10.1002/jor.22707

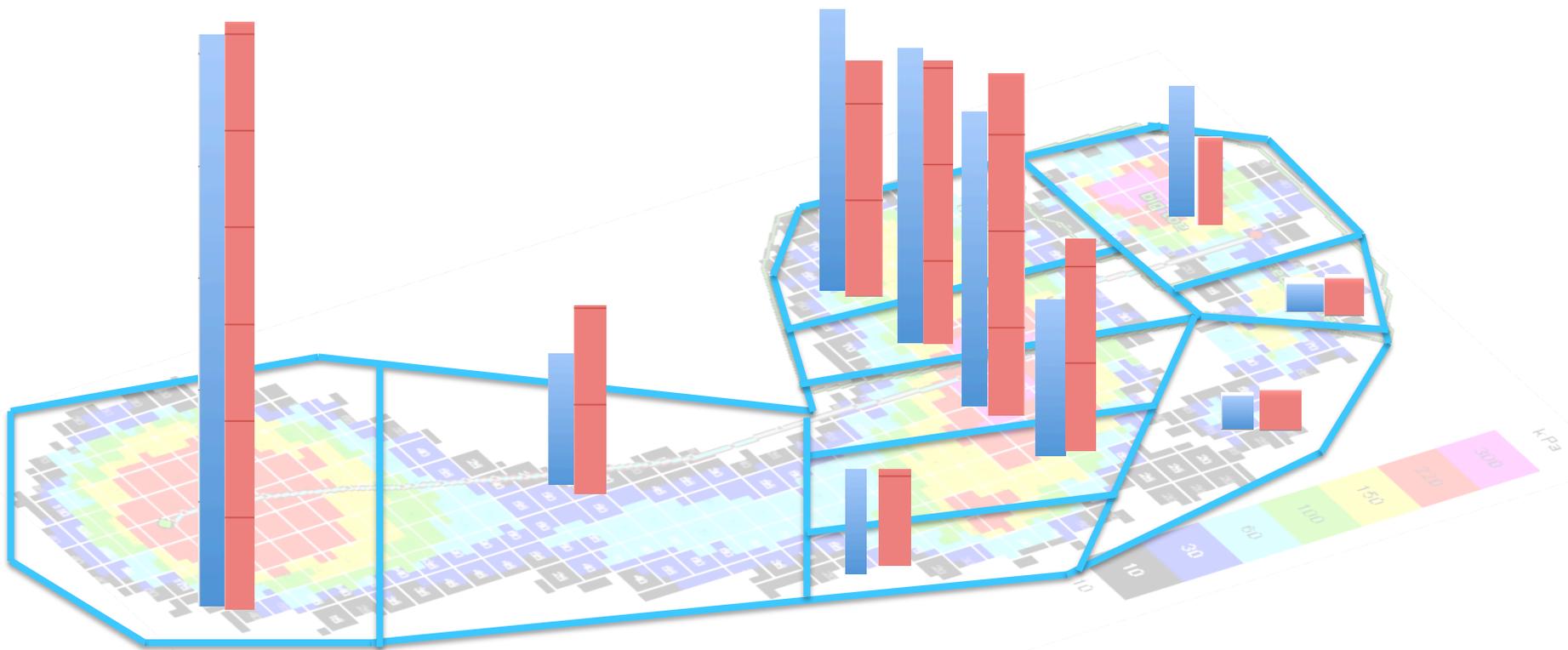


JOURNAL OF ORTHOPAEDIC RESEARCH MONTH 2014

Deformity – Plantar pressure

	Intermetatarsal Angle	Sesamoid Subluxation	Hallux Valgus Angle
Sesamoid subluxation	$r = 0.540, p < 0.001$		
Hallux valgus angle	$r = 0.540, p < 0.001$		
Intermetatarsal angle		$r = 0.561, p < 0.001$	$r = 0.484, p < 0.001$
Severity	$r = 0.909, p < 0.001$	$r = 0.451, p < 0.001$	$r = 0.478, p < 0.001$
Peak pressure total			$r = 0.285, p < 0.032$
Peak pressure lateral midfoot			$r = 0.341, p < 0.009$
Peak pressure forefoot			$r = 0.336, p < 0.011$
Peak pressure hallux			$r = -0.301, p < 0.023$
Peak pressure MH 5			$r = 0.361, p < 0.006$
Peak pressure toe three to five		$r = 0.279, p < 0.045$	
Max force lateral midfoot			$r = 0.431, p < 0.001$
Max force hallux			$r = -0.481, p < 0.001$
Max force MH 1		$r = 0.294, p < 0.034$	
Max force MH 5			$r = 0.430, p < 0.001$
Contact time medial midfoot			$r = 0.297, p < 0.025$
Contact time Hallux			$r = -0.448, p < 0.001$
Contact time toe three to five		$r = 0.283, p < 0.042$	
Contact area lateral midfoot			$r = 0.303, p < 0.022$
Contact area hallux		$r = -0.323, p < 0.020$	$r = -0.581, p < 0.001$
Contact area MH 5		$r = 0.289, p < 0.037$	$r = 0.307, p < 0.020$
Force time integral lateral midfoot			$r = 0.431, p < 0.001$
Force time integral hallux			$r = -0.435, p < 0.001$
Force time integral MH 5			$r = 0.348, p < 0.001$

Force time integral

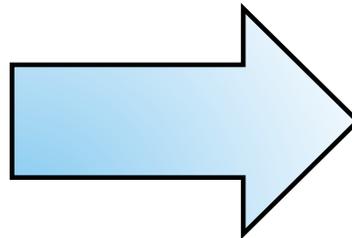
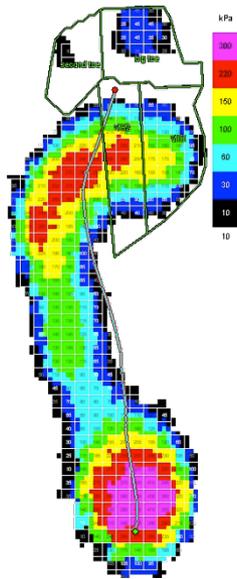


■ normal

■ Hallux valgus

Metatarsalgia

unphysiological plantar pressure patterns
may cause metatarsalgia



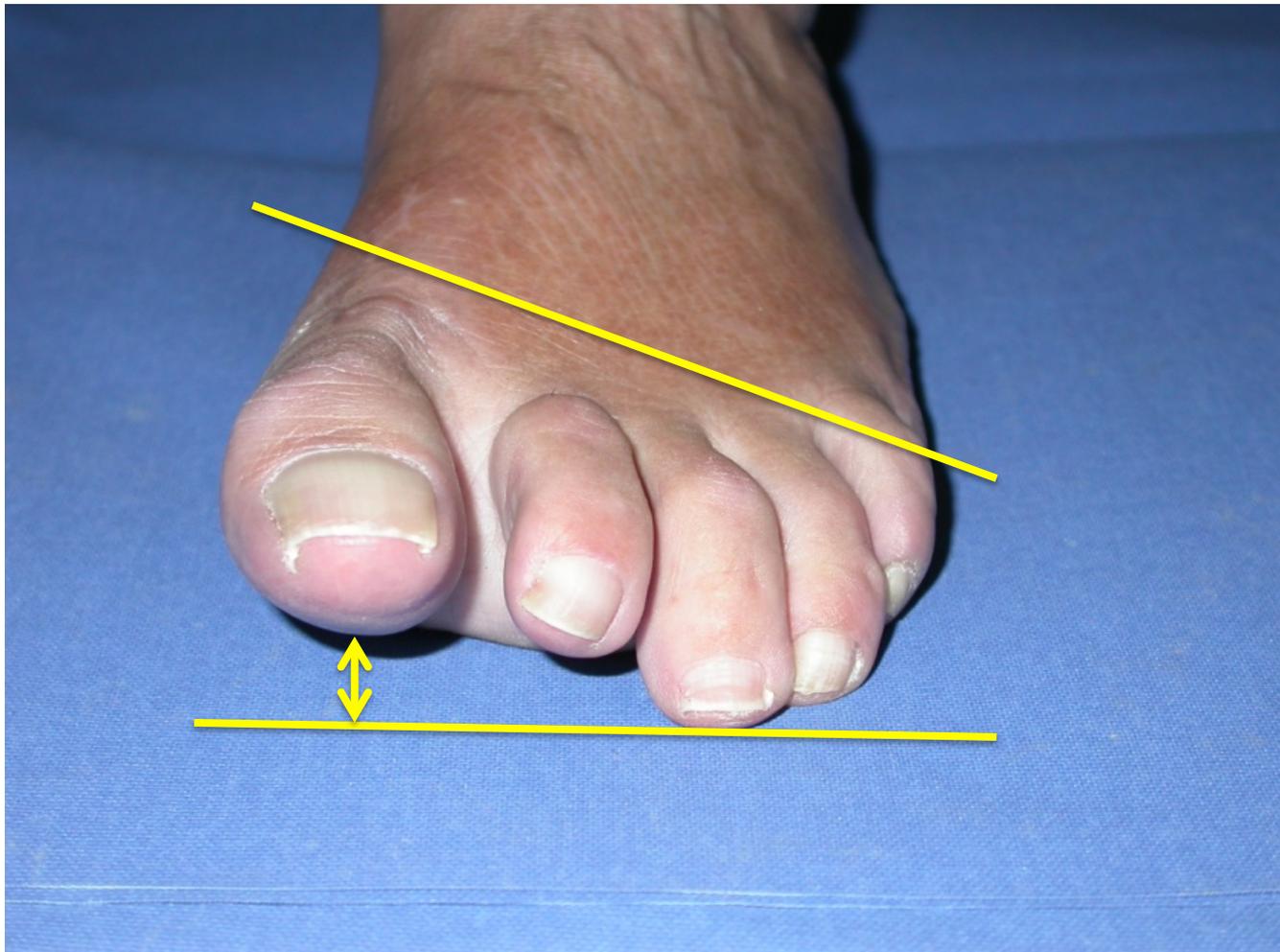
Blomgren, M. et al.: *Gait analysis in hallux valgus*. J Foot Surg 1991

Henry & Waugh: *The Use Of Footprints in Assessing The Results Of Operations For Hallux Valgus*. JBJS Br.1975

Waldecker, U.: *Metatarsalgia in hallux valgus deformity: a pedographic analysis*.Foot Ankle Surg. 2002

*„Something that
looks normal
propably works
normal“*

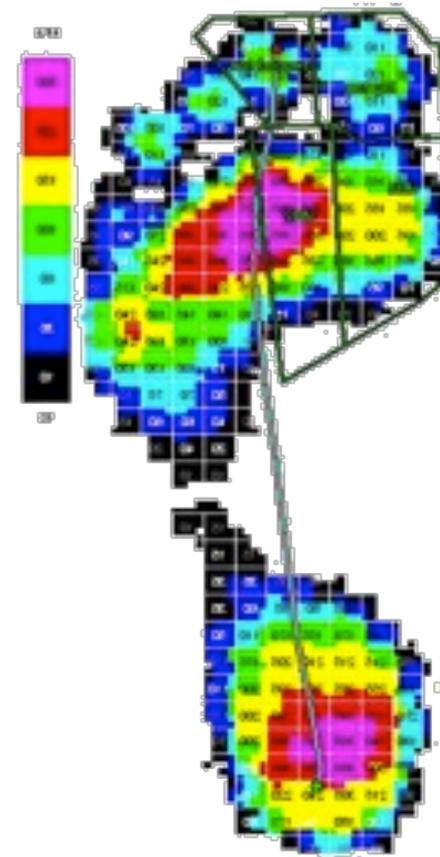
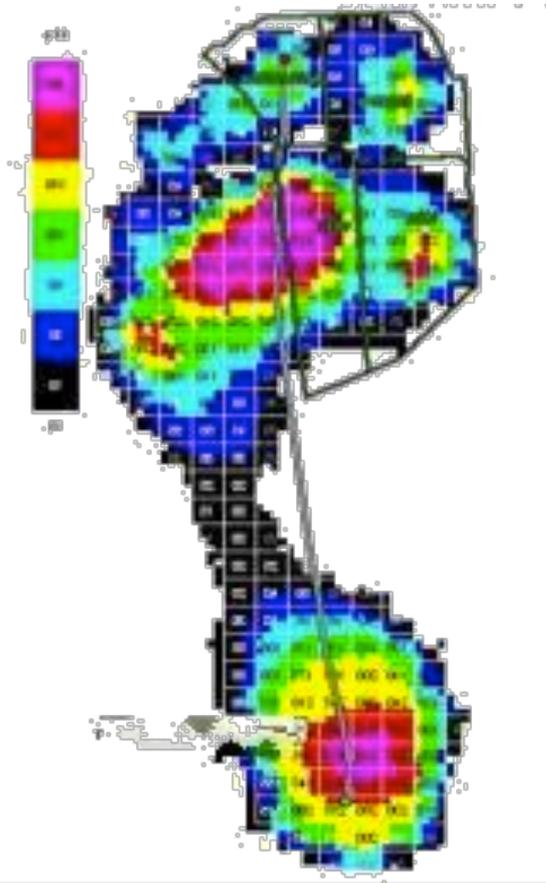
Sigvard T. Hanson



Hallux valgus - PPD

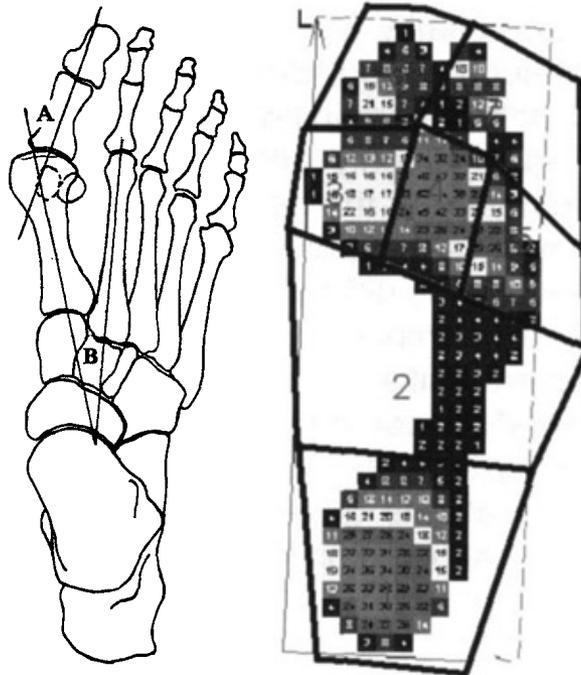
presurgically

6 months
postsurgically



Chevron (Austin) Distal Metatarsal Osteotomy for Hallux Valgus: Comparison of Pre- and Post-Surgical Characteristics

Thomas W. Kernozek, Ph.D.^{1,2}; Steven A. Sterriker, DPM, MS³
La Crosse, WI, and Waco, TX



**Plantar pressure
distribution after
Chevron osteotomy**

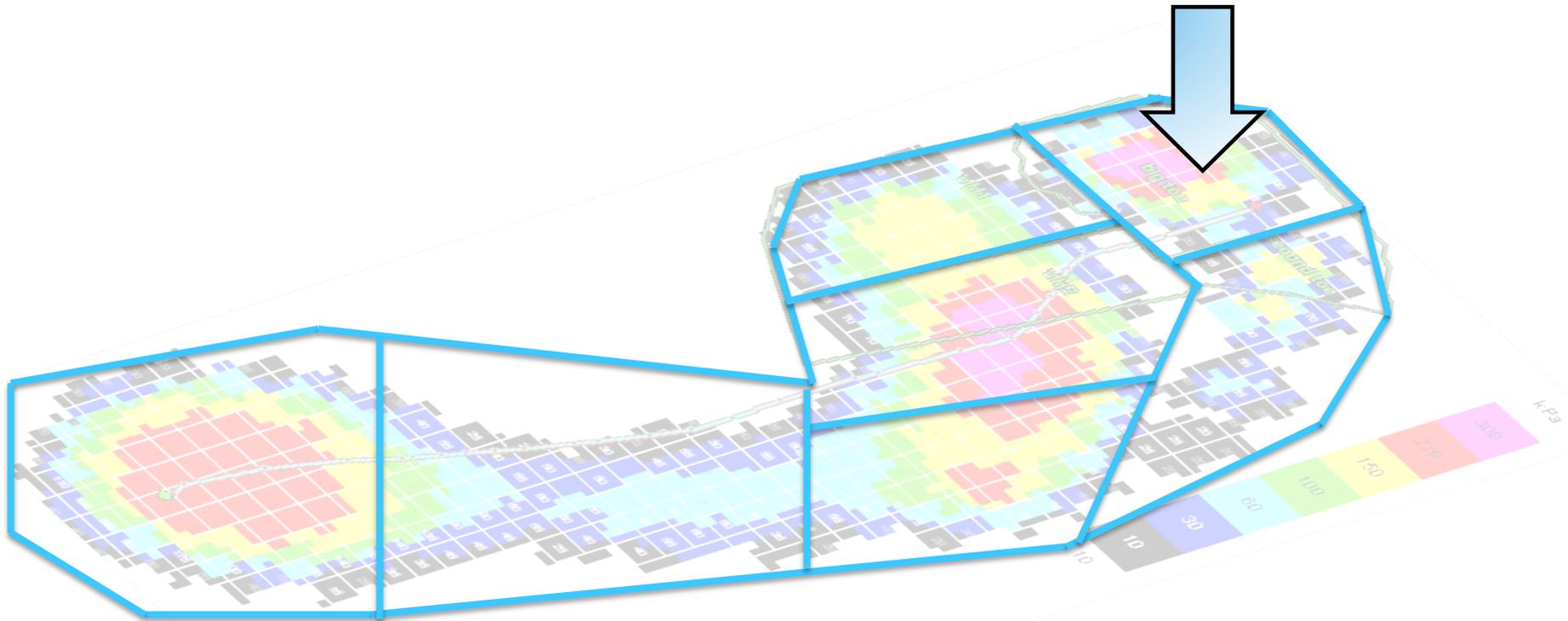
Plantar pressure parameters

Table 1: Regional plantar loading means and standard deviations pre and 12 months postsurgically for the Chevron (Austin) osteotomy for the correction of hallux valgus for the forefoot and toe regions.

Variable	Peak Force (%BW)		Force Time Integral (%BW*s)		Peak Pressure (Kpa)		Pressure Time Integral (KPa*s)		Contact Time (ms)		Contact Area (cm ²)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Condition MFF Region	23.5 (6.1)	25.2 (5.8)	8.5 (5.8)	8.6 (2.8)	360.8 (156.8)	436.2 (203.1)	128.5 (55.2)	149.4 (75.4)	670.5 (93.1)	631.1 (116.2)	15.0 (2.0)	14.8 (2.1)
Condition CFF Region	43.2* (6.1)	47.4* (7.4)	16.8 (3.3)	17.6 (4.7)	494.9* (186.3)	619.8* (218.7)	186.1 (73.3)	168.7 (33.1)	718.8 (99.5)	676.0 (123.7)	19.3 (2.7)	19.0 (2.8)
Condition LFF Region	14.9 (4.7)	14.9 (4.5)	5.2 (1.8)	5.4 (1.7)	252.2 (171.5)	265.6 (178.4)	87.4 (49.6)	83.9 (39.0)	695.5 (104.2)	649.1 (130.1)	11.9 (1.6)	12.1 (2.1)
Condition MT Region	12.4 (7.5)	12.4 (6.2)	3.8* (2.1)	2.5* (1.6)	439.3* (250.5)	289.8* (169.4)	120.9* (73.2)	58.1* (38.9)	602.0* (105.8)	446.9* (138.3)	9.2 (2.0)	9.5 (1.8)
Condition LT Region	7.6 (5.6)	9.1 (4.4)	2.1 (1.2)	2.1 (1.2)	160.4 (79.7)	202.3 (96.3)	47.0 (25.0)	58.1 (33.3)	589.8 (113.9)	582.8 (145.1)	11.2* (3.6)	12.8* (4.2)

* indicates significant differences ($p < 0.05$).

Force time integral





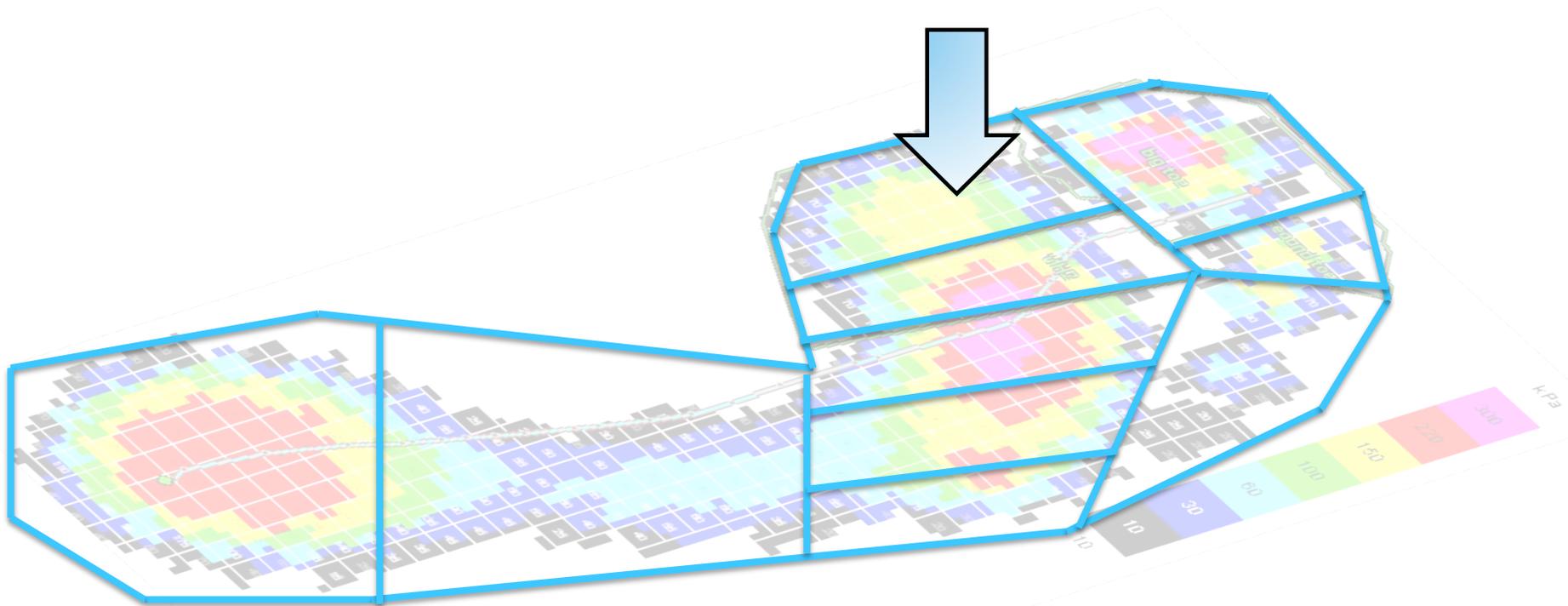
Scarf osteotomy for hallux valgus

A PROSPECTIVE CLINICAL AND PEDOBAROGRAPHIC STUDY

**Plantar pressure
distribution after Scarf
osteotomy**



Peak pressure



Dynamic Plantar Pressure Analysis and Midterm Outcomes in Percutaneous Correction for Mild Hallux Valgus

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Plantar pressure
distribution after
percutaneous (MIS)
surgery

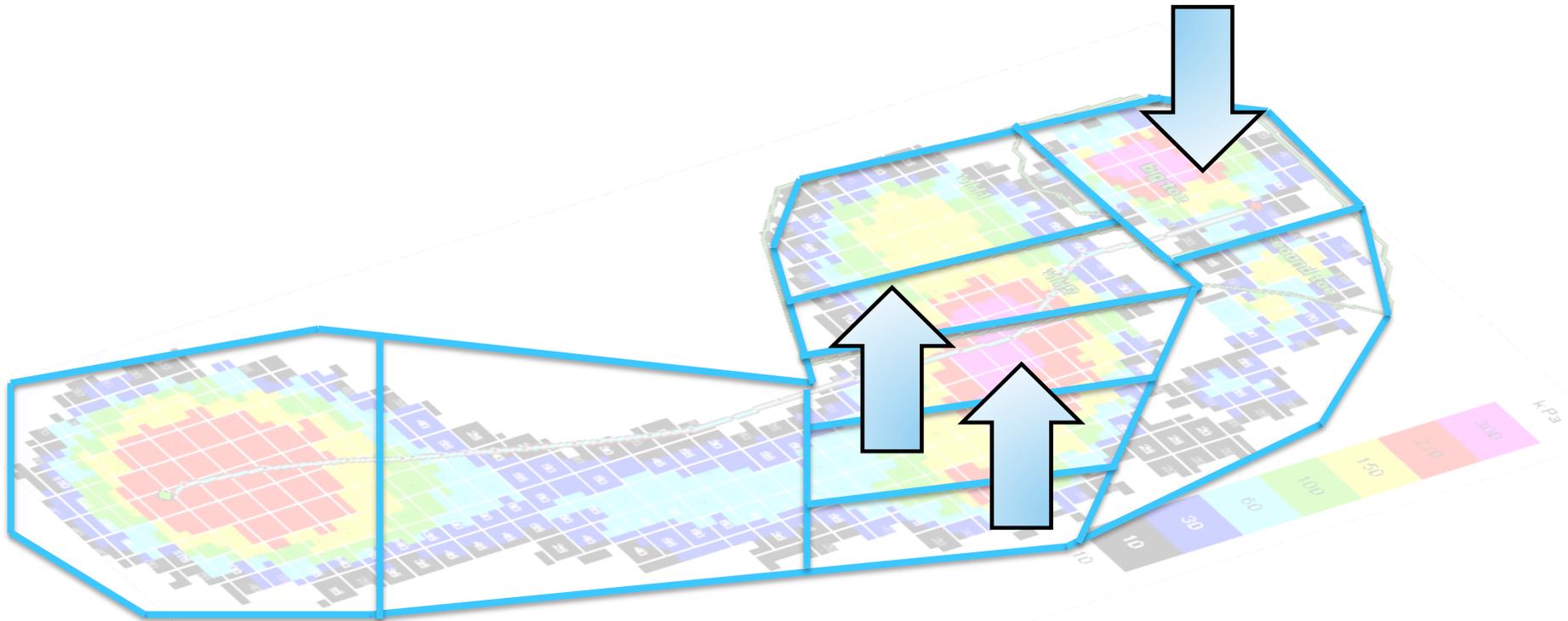
JOURNAL OF ORTHOPAEDIC RESEARCH NOVEMBER 2011

Peak pressure

Mean \pm SD ($n = 79$)

Zone	Pre-Operative	Post-Operative	<i>p</i>
1st MTH	376 \pm 207	360 \pm 208	0.552
2nd MTH	421 \pm 288	412 \pm 200	0.327
3rd MTH	381 \pm 264	391 \pm 213	0.727
4th MTH	252 \pm 196	322 \pm 215	0.002*
5th MTH	139 \pm 119	176 \pm 133	0.001*
Hallux	328 \pm 113	152 \pm 38	0.001*
Lesser toes	97 \pm 69	102 \pm 82	0.234

Peak pressure



Effects of the Lapidus Arthrodesis and Chevron Bunionectomy on Plantar Forefoot Pressures



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³ Program Director, Kaiser San Francisco Bay Area Foot and Ankle Residency, Kaiser Foundation Hospital, Oakland, CA

Plantar pressure
distribution after
Lapidus or Chevron OT

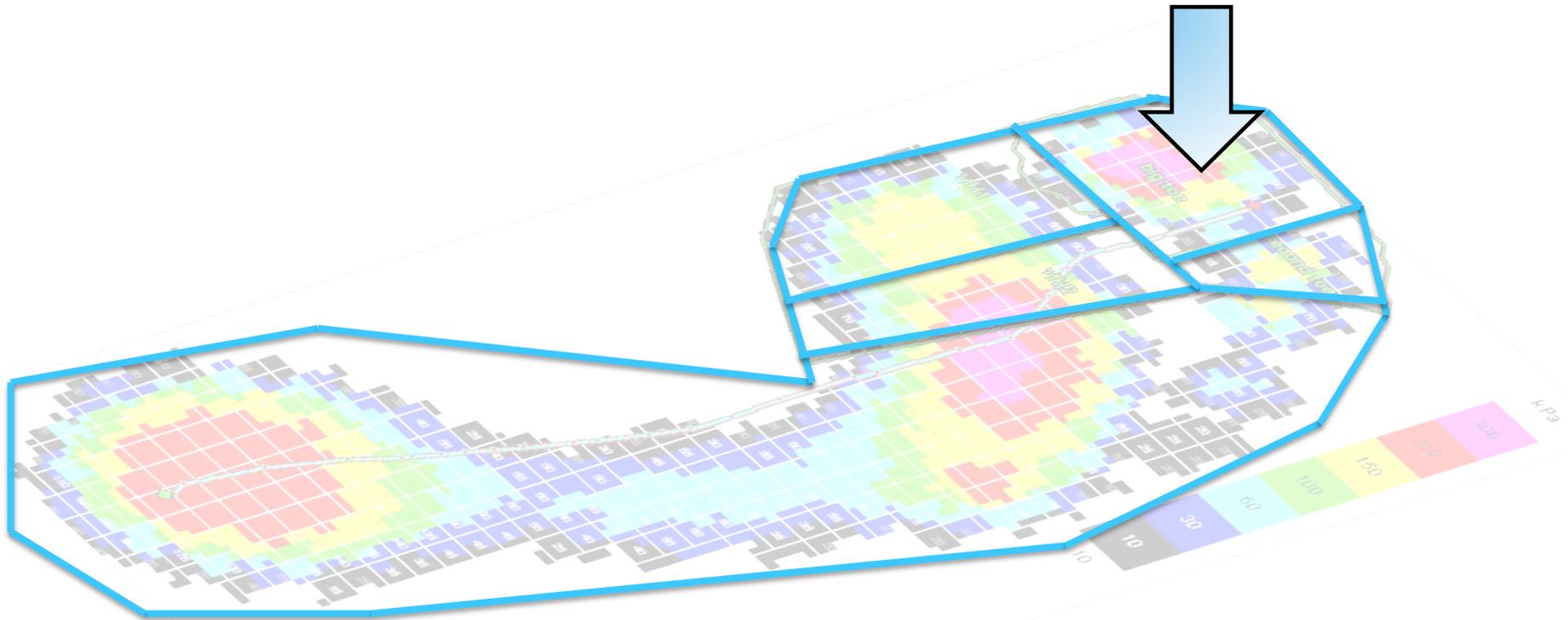


Peak pressure

Location	Lapidus (n = 34 feet)		
	Preoperative (N/cm ²)	Postoperative (N/cm ²)	p Value
Hallux	25.29 ± 9.23	17.34 ± 9.94	< .001*
First metatarsal head	20.98 ± 8.19	22.86 ± 8.80	.17
Second metatarsal head	31.84 ± 8.89	29.48 ± 8.84	.09
Third metatarsal head	23.18 ± 8.65	22.03 ± 8.36	.45
Fourth metatarsal head	17.69 ± 7.12	16.82 ± 5.63	.39
Fifth metatarsal head	14.52 ± 6.47	17.72 ± 8.84	.008*
Midfoot	8.89 ± 4.37	9.66 ± 3.86	.15
Heel	25.65 ± 6.02	24.76 ± 7.57	.34

Location	Chevron (n = 34 feet)		
	Preoperative (N/cm ²)	Postoperative (N/cm ²)	p Value
Hallux	25.20 ± 8.32	18.47 ± 9.57	< .001*
First metatarsal head	19.42 ± 8.21	19.30 ± 7.02	.93
Second metatarsal head	31.30 ± 7.87	30.76 ± 9.49	.67
Third metatarsal head	24.26 ± 5.84	25.18 ± 6.74	.32
Fourth metatarsal head	17.88 ± 5.93	18.71 ± 7.03	.40
Fifth metatarsal head	16.30 ± 8.41	17.17 ± 8.82	.44
Midfoot	7.58 ± 5.23	7.41 ± 3.97	.82
Heel	26.65 ± 5.88	28.50 ± 7.19	.06

Peak pressure



Biomechanics of postoperative shoes: plantar pressure distribution, wearing characteristics and design criteria: a preliminary study

Reinhard Schuh · Hans-Joerg Trnka ·
Anton Sabo · Martin Reichel · Karl-Heinz Kristen



1. Rathgeber® normal



2. Rathgeber® modified



3. Darco® VFE



4. Darco® flat



5. Wocker®

Effectiveness and
comfort of forefoot
relief shoes

Methods

8 healthy volunteers (5 male/3 female)

Mean age: 26 (21 – 28)

Mediologic™ (T&T medilogic Medizintechnik GmbH, Unterschleissheim, Germany) insoles have been inserted in the shoes

30 8-bit sensors, maximum pressure of 64 N/cm².

Data collection: 50 Hz

Data recorded on 15 m walkway

Compared to off-the-shelf nordic walking shoe (Reference shoe)

Models



1. Rathgeber® normal



2. Rathgeber® modified



3. Darco® VFE

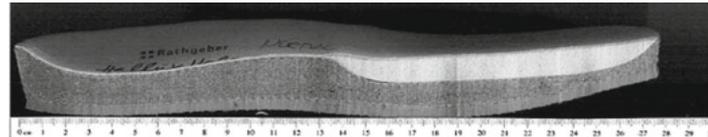


4. Darco® flat

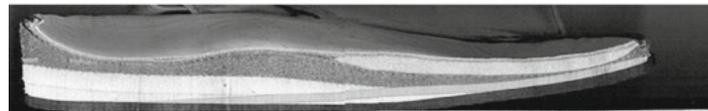


5. Wocker®

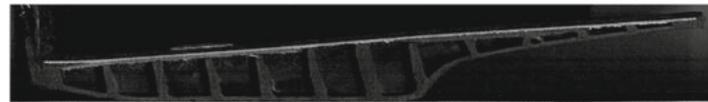
(b)



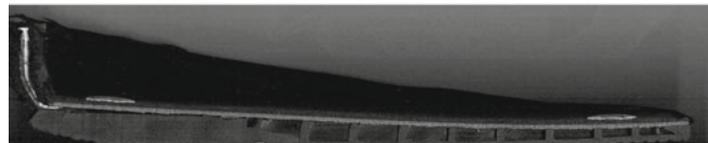
Rathgeber® normal



Rathgeber® modified



Darco® VFE



Darco® flat



Wocker®

Outcome parameters

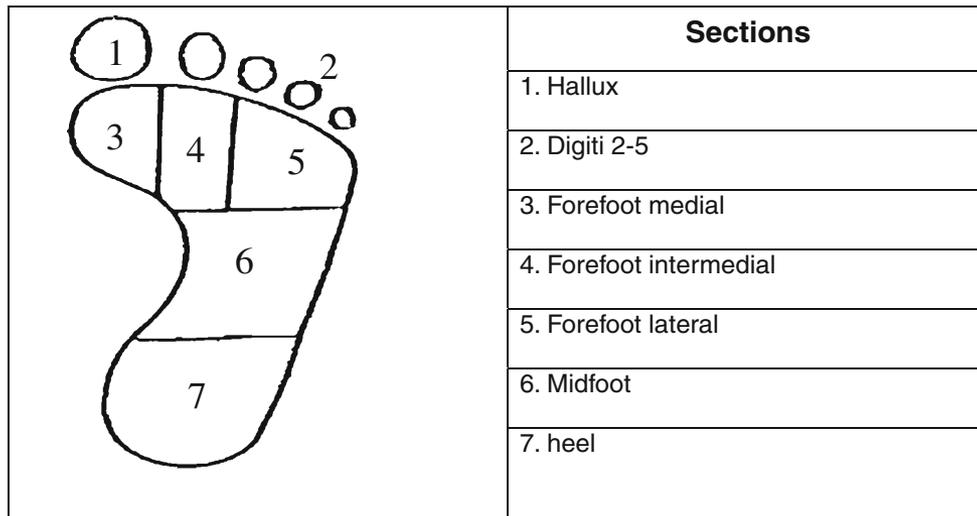


Fig. 2 Biomechanical sections of the foot according to Nyska et al. [14]

Stability

Rolling
characteristics

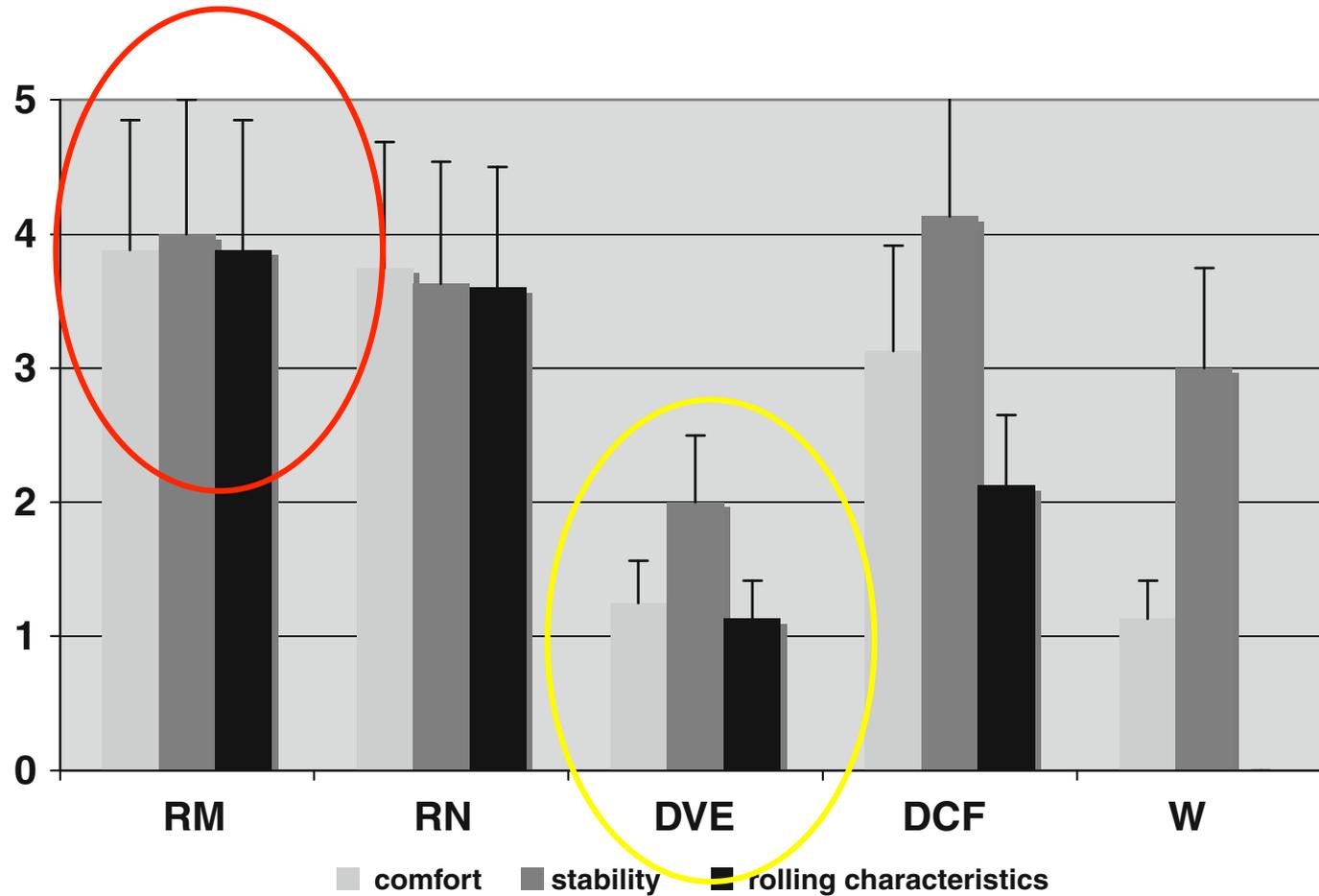
Wearing comfort

Grading: 1 - 5

Plantar pressure parameters

Shoe type	Abbreviation	Mean pressure (N/cm ²)		Peak pressure (N/cm ²)	
		Hallux	Forefoot	Hallux	Forefoot
Rathgeber normal	RN	5.6 (1.7)*	5.4 (1.2)*	28.7 (6.5)*	27.3 (15.5)*
Rathgeber modified	RM	5.0 (1.0)*	4.0 (1.0)*	32.3 (16.6)	17.9 (5.1)*
Darco VFE	DVF	3.7 (2.1)*	6.0 (1.1)*	16.8 (7.8)*	36.3 (14.2)
Darco flat	DF	7.3 (1.9)	8.1 (1.9)*	49.7 (11.8)	49.2 (12.7)
Wocker	W	6.4 (2.0)*	7.5 (1.4)*	38.8 (16.7)	39.9 (12.1)
Barefoot	WF	10.3 (3.6)*	11.1 (1.7)*	51.7 (12.6)	53.0 (11.9)
Reference shoe	RS	15.0 (2.2)	7.6 (1.3)	45.0 (8.3)	42.1 (9.4)
Negative heel	NH	4.8 (1.0)*	5.1 (1.1)*	30.4 (7.0)*	19.7 (6.9)*
Extra cushioning	SS	5.2 (0.7)*	4.9 (1.0)	31.5 (11.6)	19.2 (6.0)*
Antipronation	AP	5.6 (1.3)	5.5 (1.2)	33.1 (7.9)*	27.85 (6.4)*
Carbon	C	7.6 (2.1)	5.5 (1.8)	39.0 (11.6)	21.6 (6.5)*

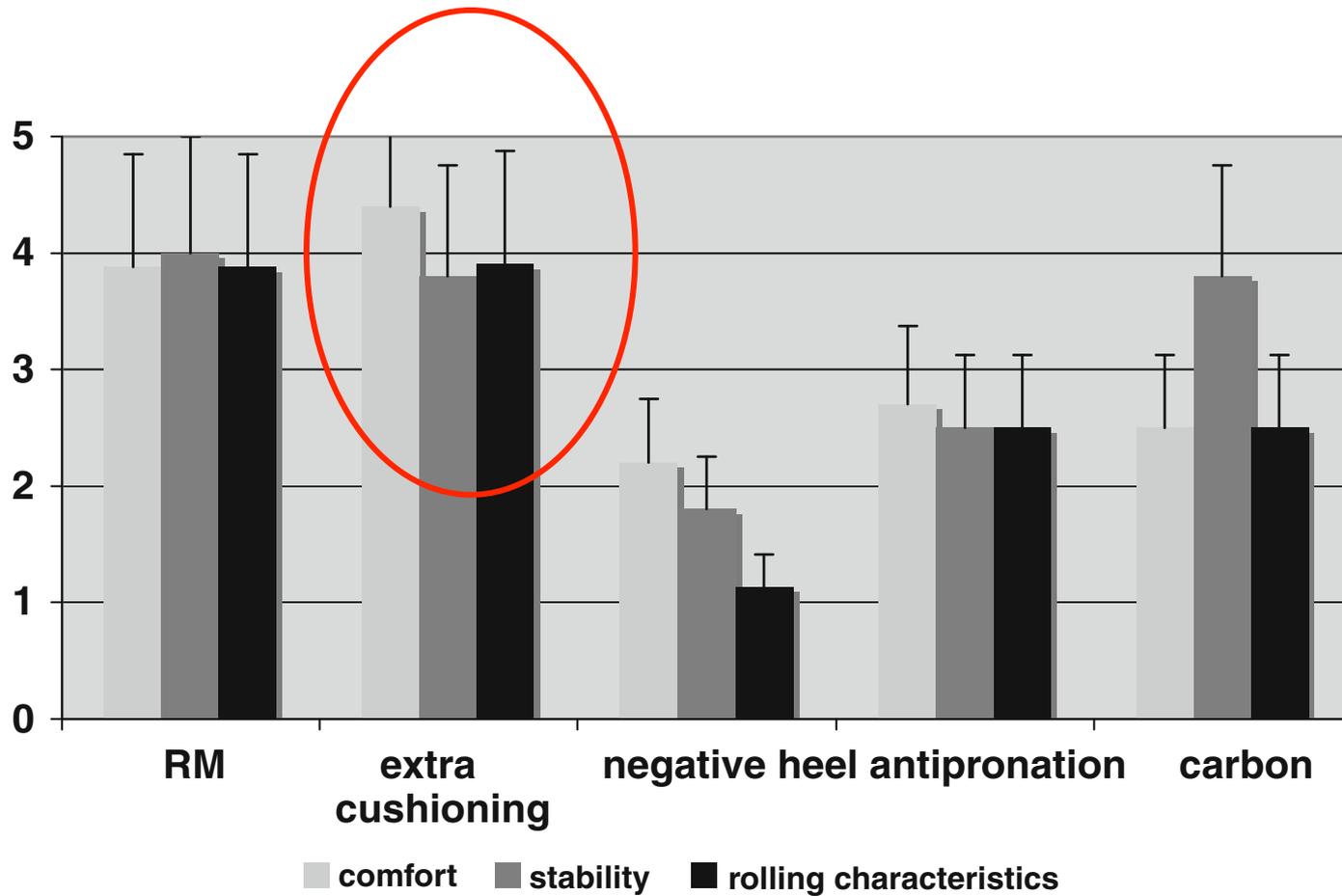
Wearing characteristics



Plantar pressure parameters

Shoe type	Abbreviation	Mean pressure (N/cm ²)		Peak pressure (N/cm ²)	
		Hallux	Forefoot	Hallux	Forefoot
Rathgeber normal	RN	5.6 (1.7)*	5.4 (1.2)*	28.7 (6.5)*	27.3 (15.5)*
Rathgeber modified	RM	5.0 (1.0)*	4.0 (1.0)*	32.3 (16.6)	17.9 (5.1)*
Darco VFE	DVF	3.7 (2.1)*	6.0 (1.1)*	16.8 (7.8)*	36.3 (14.2)
Darco flat	DF	7.3 (1.9)	8.1 (1.9)*	49.7 (11.8)	49.2 (12.7)
Wocker	W	6.4 (2.0)*	7.5 (1.4)*	38.8 (16.7)	39.9 (12.1)
Barefoot	WF	10.3 (3.6)*	11.1 (1.7)*	51.7 (12.6)	53.0 (11.9)
Reference shoe	RS	15.0 (2.2)	7.6 (1.3)	45.0 (8.3)	42.1 (9.4)
Negative heel	NH	4.8 (1.0)*	5.1 (1.1)*	30.4 (7.0)*	19.7 (6.9)*
Extra cushioning	SS	5.2 (0.7)*	4.9 (1.0)	31.5 (11.6)	19.2 (6.0)*
Antipronation	AP	5.6 (1.3)	5.5 (1.2)	33.1 (7.9)*	27.85 (6.4)*
Carbon	C	7.6 (2.1)	5.5 (1.8)	39.0 (11.6)	21.6 (6.5)*

Wearing characteristics





Rehabilitation After Hallux Valgus Surgery: Importance of Physical Therapy to Restore Weight Bearing of the First Ray During the Stance Phase

Reinhard Schuh, Stefan G. Hofstaetter, Samuel B. Adams Jr, Florian Pichler, Karl-Heinz Kristen, Hans-Joerg Trnka

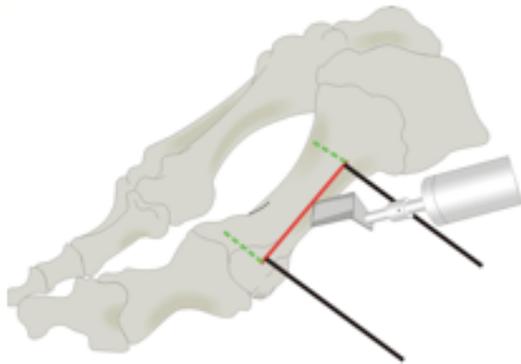
Effect of physiotherapy
after Hallux valgus
surgery



Demographics

age (mean, range)	58,4 a, 22 - 79
gender m : f	2 : 28
Surgical technique Austin : Scarf	20 : 10
Hallux valgus angle preoperatively (mean, range)	33,5°, 20° - 50°
Intermetatarsal angle preoperatively (mean, range)	14,5°, 12° - 20°

Surgical Technique



Postoperative treatment

- correctional tape
- postoperative shoe
- Weight-bearing from the day of surgery
- change of tape weekly
- duration: 4 weeks



Rehabilitation Program

Once a week

30 - 45 min

mean: 4,2; range: 4 - 6

Motor learning

Strengthening
exercise

Gait training

Mobilisation

Manual-
therapeutic
Interventions
MTP 1 joint

Soft tissue
Massage

Cryotherapy

Lymphatic
Drainage

Activation
muscle pump

Therapy



http://ptjournal.apta.org/content/suppl/2009/08/25/89.9.934.DC1/Schuh_eappendix.pdf

Outcome parameters

Plantar pressure assessment

- Presurgically
- 4 weeks postsurgically
- 8 weeks postsurgically
- 6 months postsurgically

Clinical Assessment

- AOFAS score
- ROM

Rehabilitation After Hallux Valgus Surgery

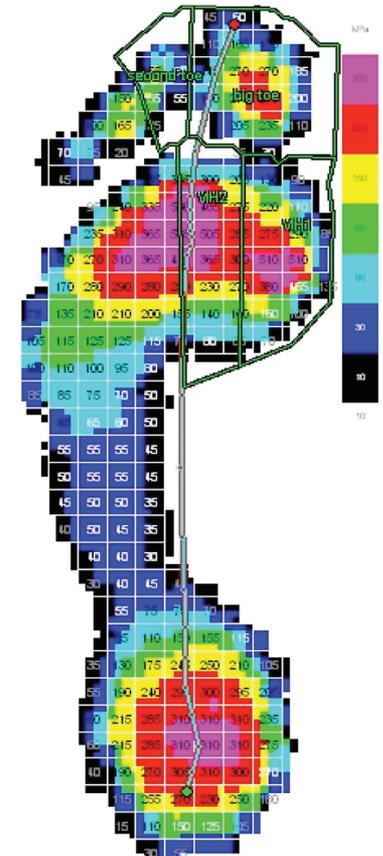


Figure 1. Plantar pressure image with regions of interest: total foot, first metatarsal head (MH1), second metatarsal head (MH2), big toe, and second toe.

Maximum Force

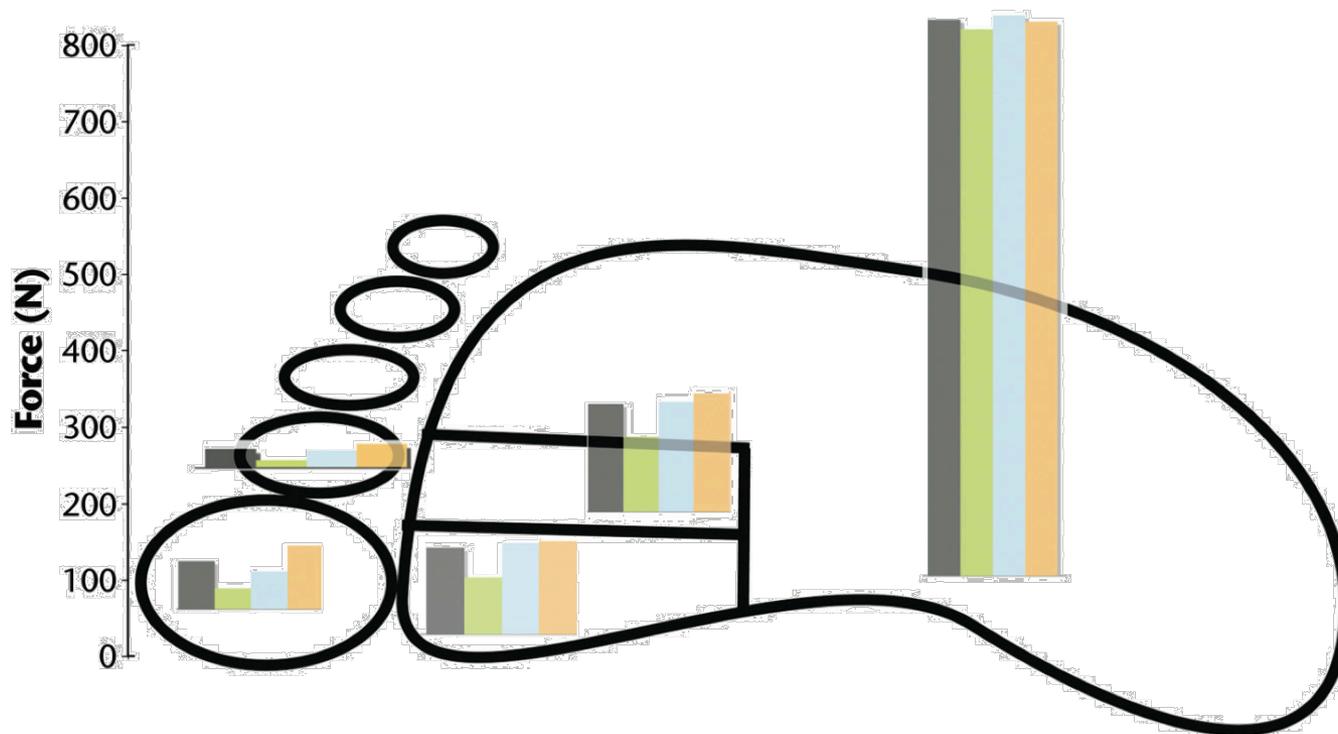
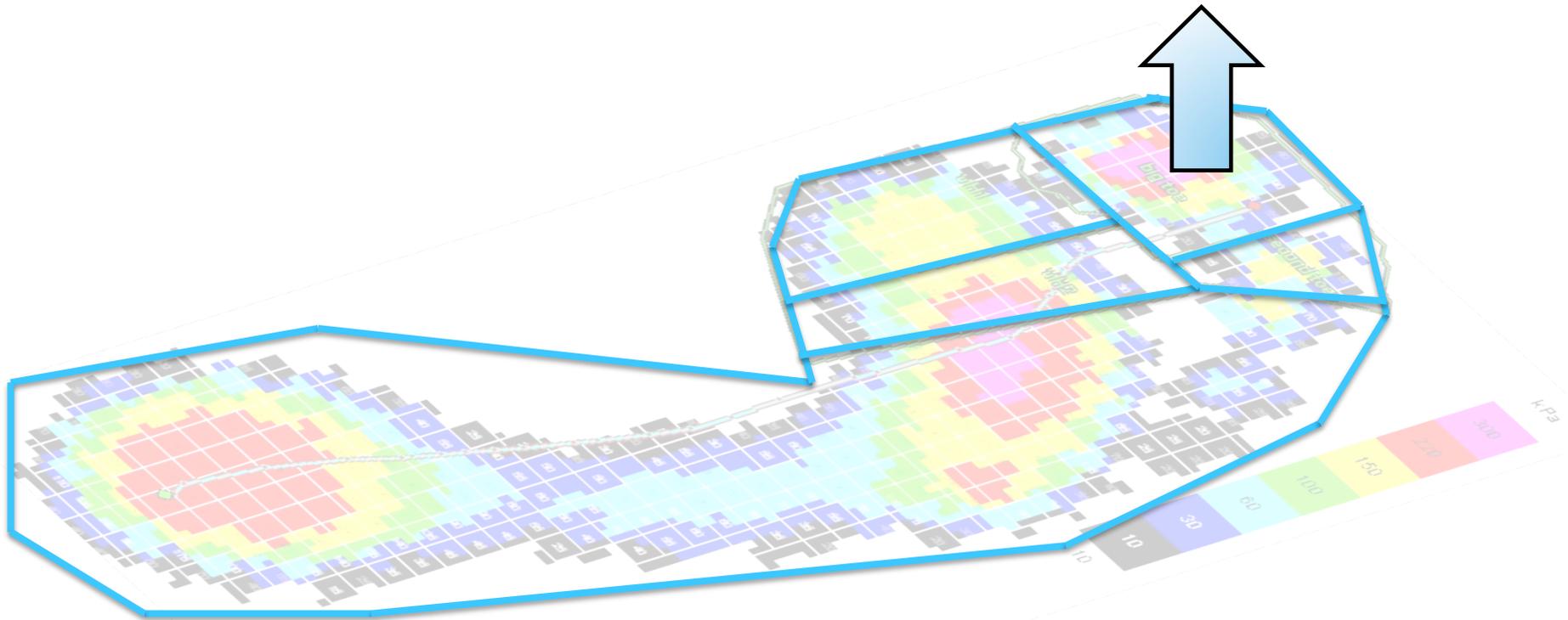


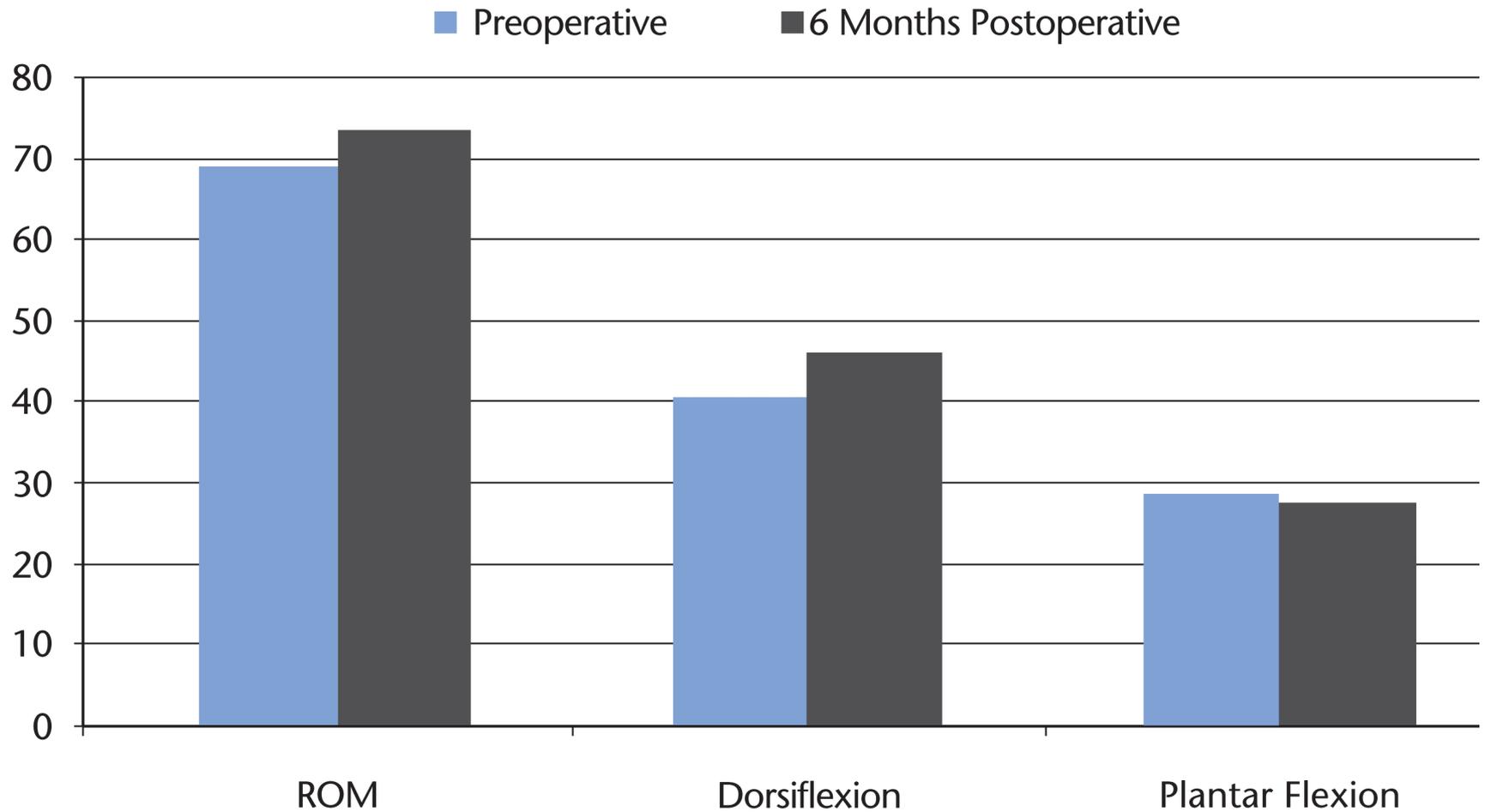
Figure 4.

Regional force changes in the treated feet: preoperative (gray), 4 weeks postoperative (green), 8 weeks postoperative (blue), and 6 months postoperative (orange).

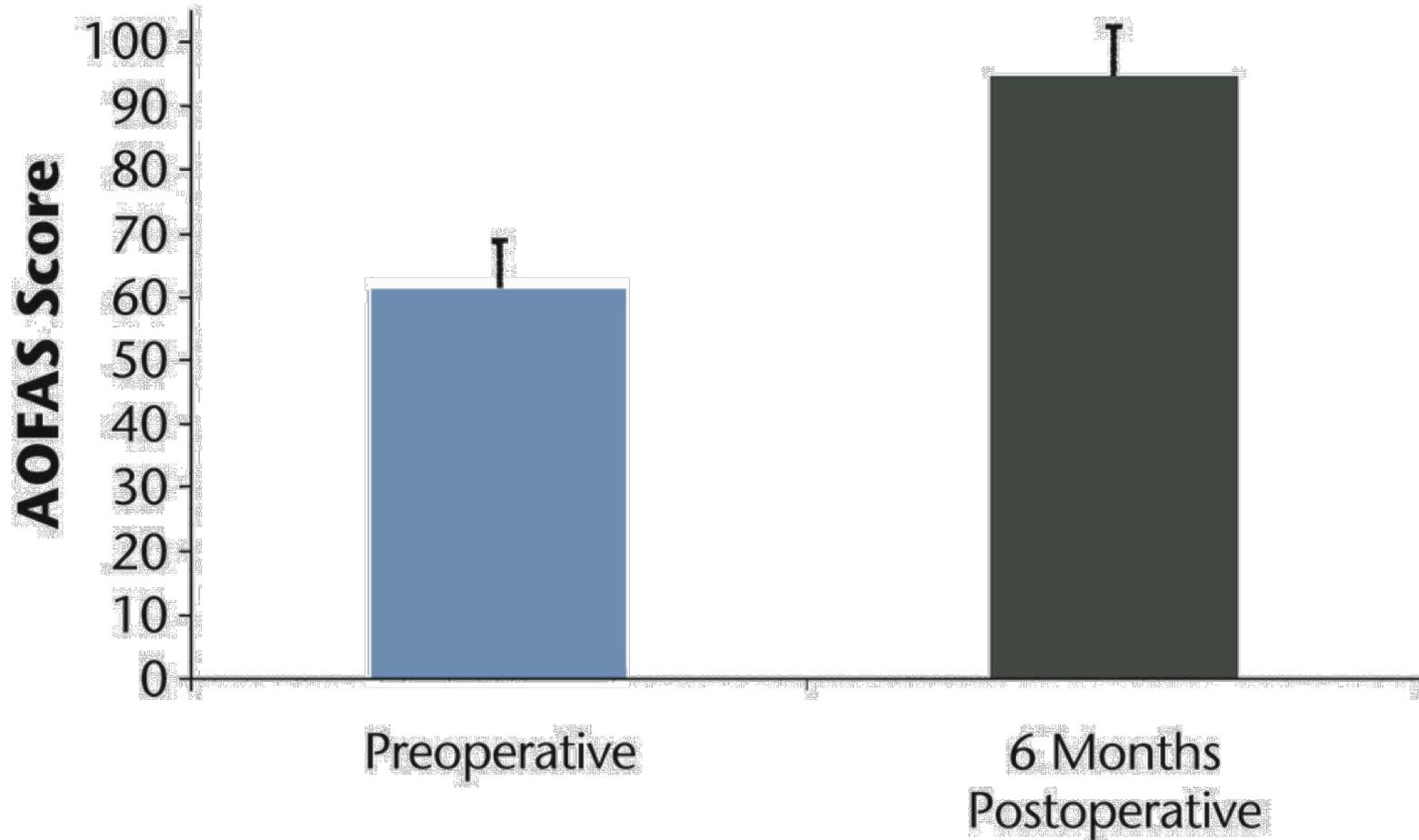
Maximum force



Range of Motion



AOFAS Score



Plantar Loading After Chevron Osteotomy Combined with Postoperative Physical Therapy

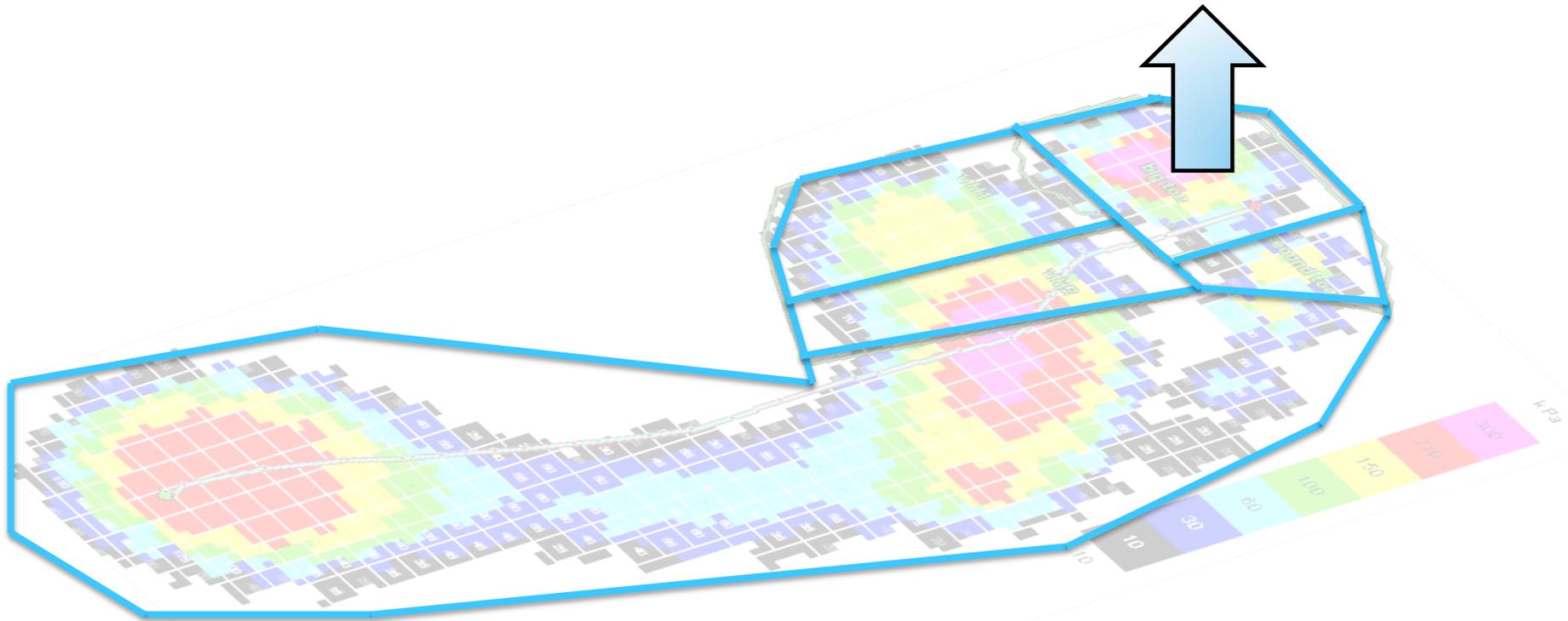
Reinhard Schuh, MD; Samuel Adams, Jr., MD; Stefan Hofstaetter, MD; Martin Krismer, MD; Hans-Joerg Trnka, MD

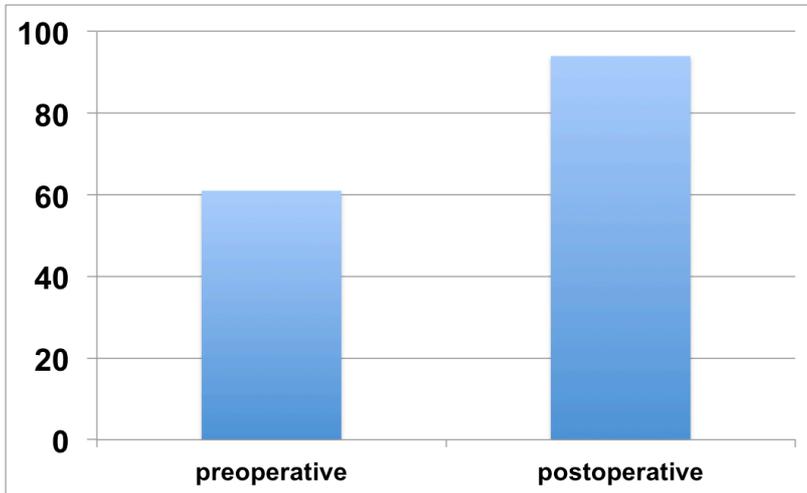
Effect of physiotherapy
on functional outcome
of Chevron Osteotomy

Demographics

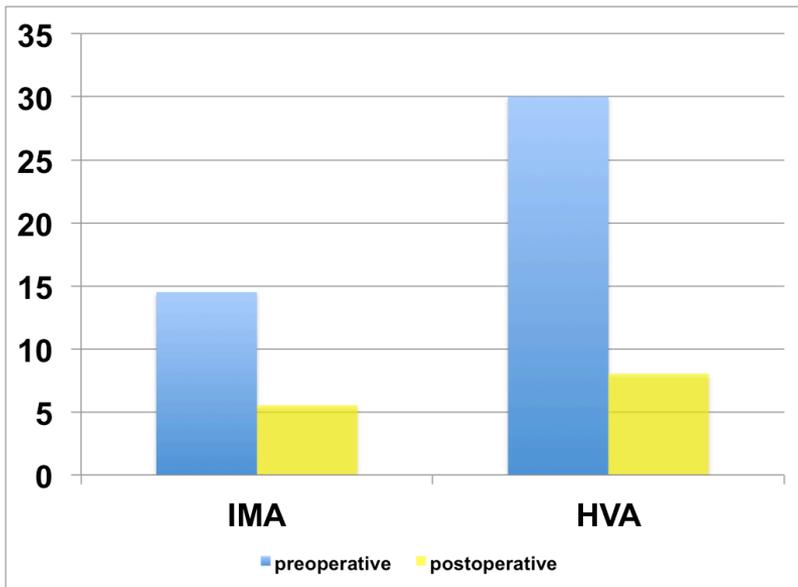
- 29 patients (29 feet) who suffered on mild to moderate hallux valgus deformity without any degenerative changes in the first MTP joint
- mean age: 58a (range: 30 – 73)
- gender distribution: m/f = 1/28
- Postsurgical treatment with modified Rathgeber postoperative shoe for 4 weeks

Maximum force





AOFAS Score

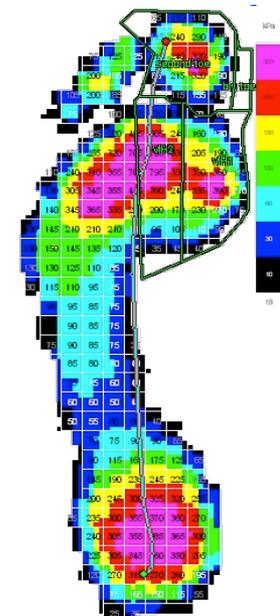
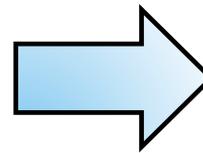


Radiographic
parameters

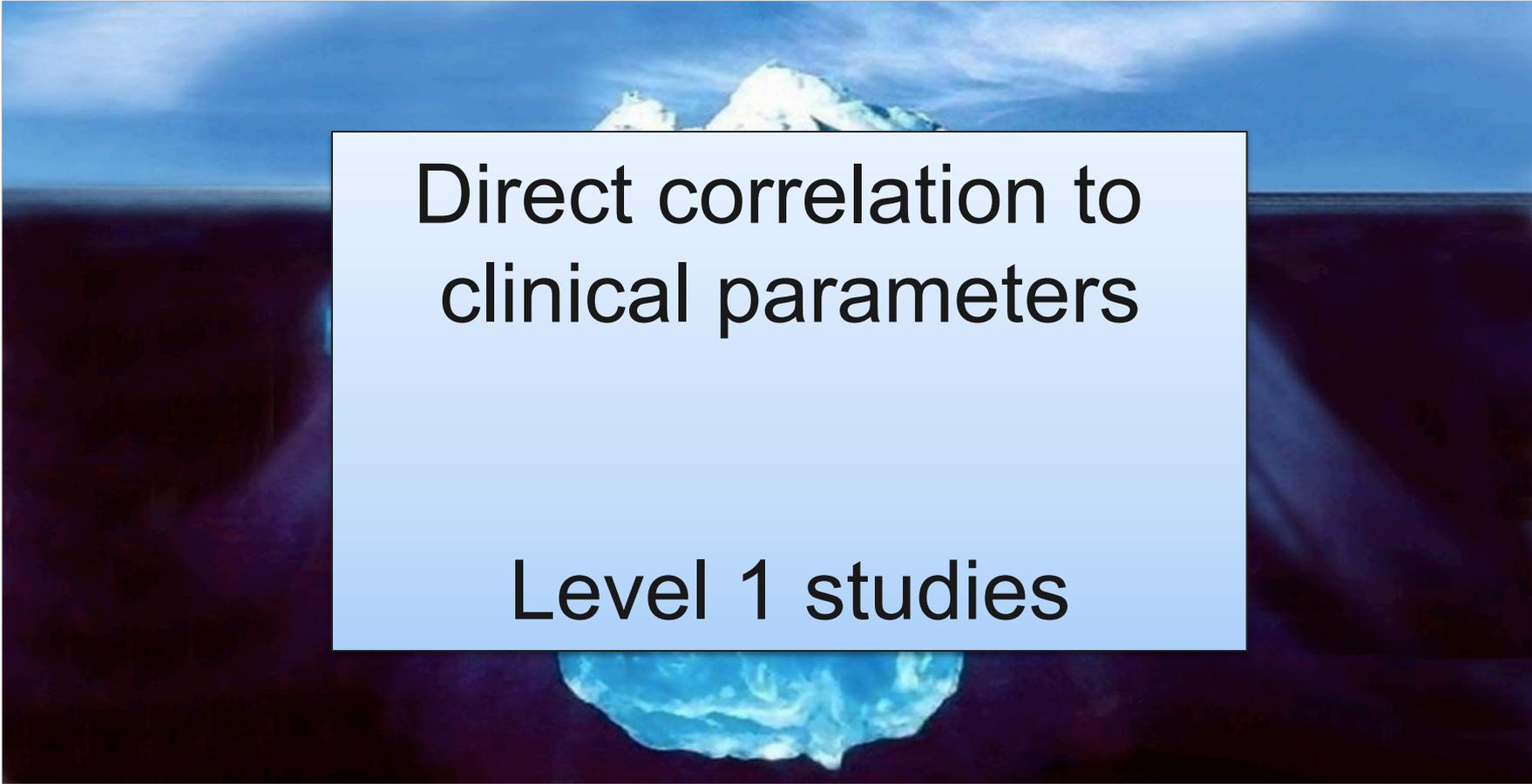
$p < 0,0001$

Conclusion

PT and multimodal rehabilitation might improve plantar pressure distribution after hallux valgus surgery



Future perspective

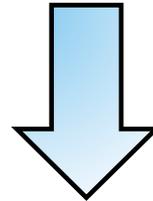


Direct correlation to
clinical parameters

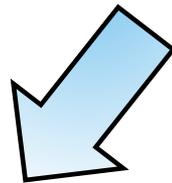
Level 1 studies

Prospective RCT

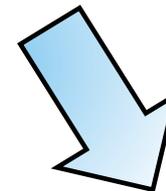
50 patients (IMA < 16°)



Austin Osteotomy



Multimodal rehabilitation
programm (4 session within 1
month)



controls

Further reading

Koller U, Willegger M, Windhager R, Wanivenhaus A, Trnka HJ, Schuh R. **Plantar pressure characteristics in hallux valgus feet.** J Orthop Res. 2014 Dec;32(12):1688-93. doi: 10.1002/jor.22707. Epub 2014 Aug 11. PubMed PMID: 25130961.

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Schuh R, Hofstaetter SG, Adams SB Jr, Pichler F, Kristen KH, Trnka HJ. **Rehabilitation after hallux valgus surgery: importance of physical therapy to restore weight bearing of the first ray during the stance phase.** Phys Ther. 2009 Sep;89(9):934-45. doi: 10.2522/ptj.20080375. Epub 2009 Jul 16. PubMed PMID: 19608631.
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THANK
YOU

Department of Orthopedics

