

# Indications for Shockwaves In Veterinary Medicine

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DACVS, DACVSMR

**IOWA STATE UNIVERSITY**  
College of Veterinary Medicine

# Indications in Veterinary Medicine

- Bone - Tendon/Ligament interfaces
- Sole use or in combination with other regenerative therapies
- Other “positive biologic” applications
  - Wounds
  - Implants

## Effect of shock-wave therapy on patellar tendinopathy in a rabbit model

Robert Wen-Wei Hsu <sup>a,\*</sup>, Wei-Hsiu Hsu <sup>a</sup>, Ching-Lung Tai <sup>b</sup>, Kam-Fai Lee <sup>c</sup>

<sup>a</sup> Department of Orthopedic Surgery, Chang Gung Memorial Hospital at Chia-Yi, Chang Gung University, Chia-Yi, 613 Taiwan

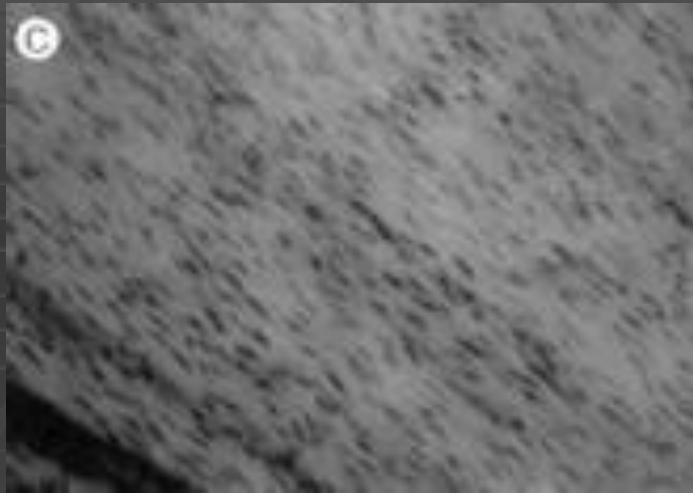
<sup>b</sup> Biomechanical Laboratory, Department of Orthopaedic Surgery, Chang Gung Memorial Hospital, Taipei, 333 Taiwan

<sup>c</sup> Department of Pathology, Chang Gung Memorial Hospital at Chia-Yi, Chia-Yi, 613 Taiwan

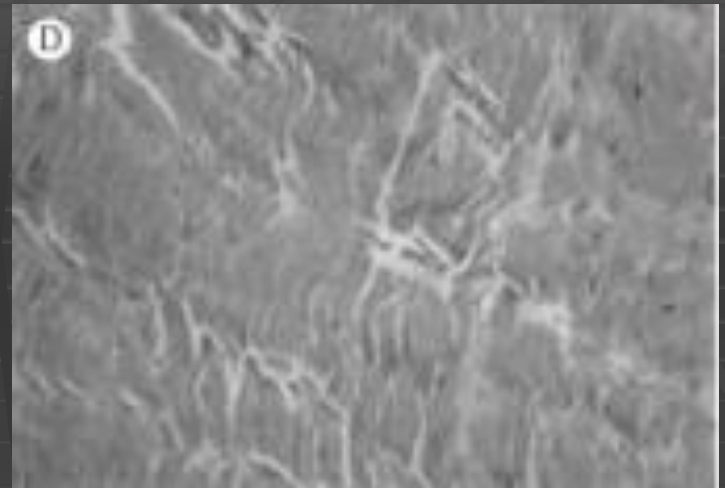
Received 6 December 2002; accepted 8 May 2003

- Collagenase induced lesions bilaterally
- ESWT 1500 pulses  
0.29 mJ/mm<sup>2</sup> 2 times
- Euthanized at 4 and 16 weeks after completion of treatment





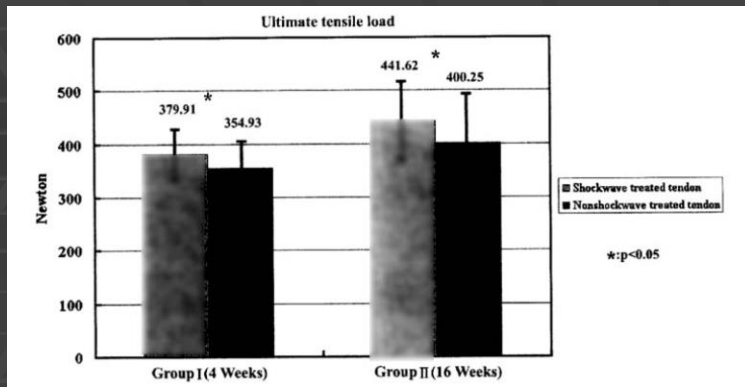
Treated



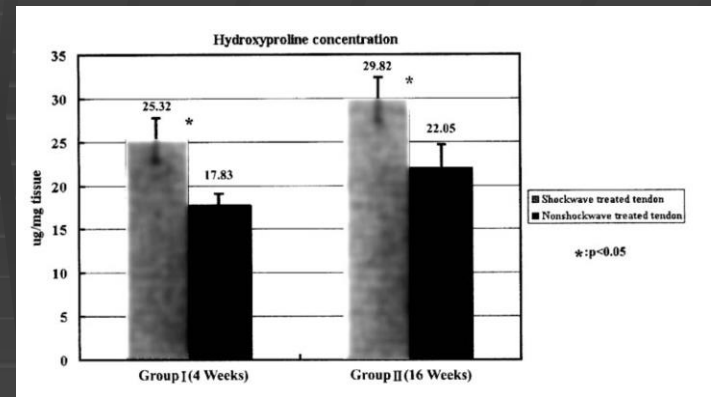
Control

- At 16 weeks increased tenocytes with more organization and neovascularization





□ 10% ↑ tensile strength at 16 weeks



□ Increased hydroxyproline content

# Shock Wave-Enhanced Neovascularization at the Tendon–Bone Junction: An Experiment in Dogs

Ching-Jen Wang, MD,<sup>1</sup> Hsuan-Ying Huang, MD,<sup>2</sup> and Chun-Hwan Pai, MD<sup>1</sup>



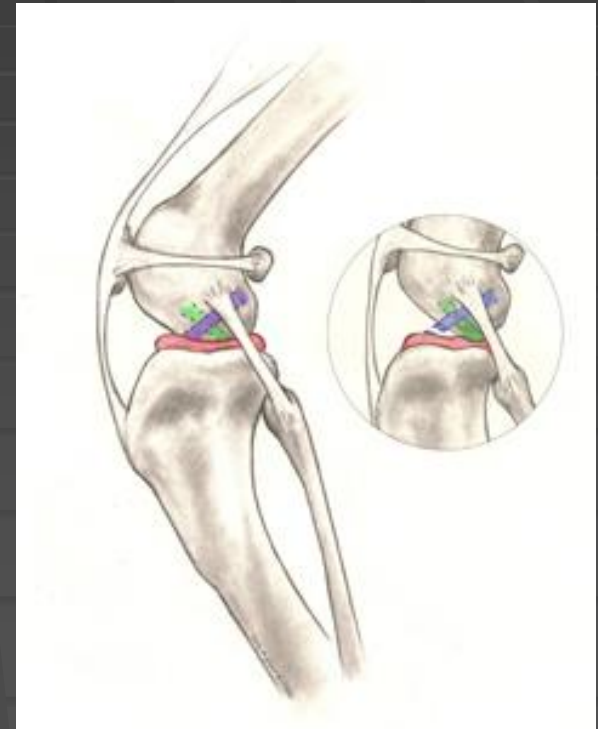
- New capillary and muscularized vessel at 4 –6 weeks post treatment
- Induce neovascularization of bone tendon junction

Wang C et al, 2002

# Prevalence of and risk factors for hip dysplasia and cranial cruciate ligament deficiency in dogs

Tige H. Witsberger, DVM; J. Armando Villamil, DVM, MS; Loren G. Schultz, DVM, MS, DACVPM;  
Allen W. Hahn, DVM, PhD, DACVIM; James L. Cook, DVM, PhD, DACVS

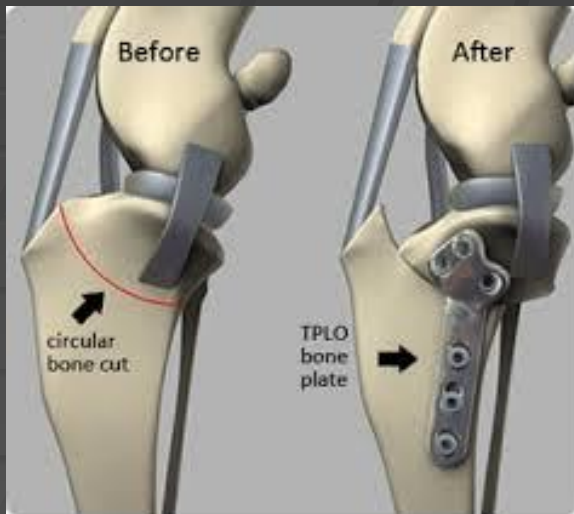
- Approximately 11% of dogs will have cruciate ligament disease





## RADIOGRAPHIC AND ULTRASONOGRAPHIC EVALUATION OF THE PATELLAR LIGAMENT FOLLOWING TIBIAL PLATEAU LEVELING OSTEOTOMY

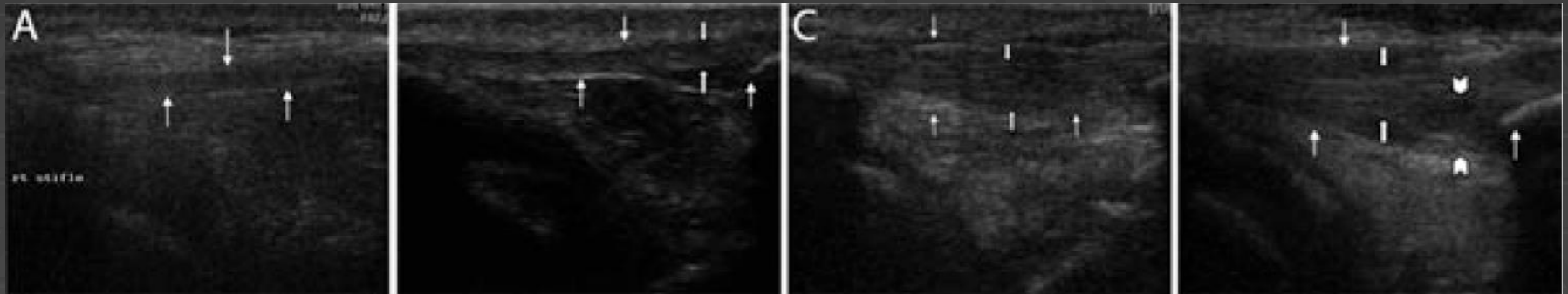
KARA L. MATTERN, CLIFFORD R. BERRY, JEFFREY N. PECK, JACEK J. DE HAAN



□ 13/27 Develop Patellar Ligament Desmitis

# The Effect of Shock Wave Therapy on Patellar Ligament Desmitis after Tibial Plateau Leveling Osteotomy

Alissa Gallagher, DVM, Alan R. Cross, DVM, Diplomate ACVS, and Gustavo Sepulveda, DVM, Diplomate ACVR



- 600 pulses, 0.18 mJ/mm<sup>2</sup>
- 5 mm depth focused electrohydraulic shock wave
- 4 and 6 weeks postoperative

Time (weeks)	Control	Treatment	P-Value
0	0.25	0.24	0.8719
4	0.77	0.64	0.2362
<b>6</b>	<b>0.87</b>	<b>0.56*</b>	<b>0.0059</b>
<b>8</b>	<b>0.83</b>	<b>0.54*</b>	<b>0.0095</b>

Least Square Means Thickness (cm) at 3/4 Distance by Group

- ❖ Patellar Ligament Desmitis
- ❖ Potential for nonunion
- ❖ Synovitis / Osteoarthritis

# THE EFFECTS OF EXTRACORPOREAL SHOCK-WAVE THERAPY ON THE ULTRASONOGRAPHIC AND HISTOLOGIC APPEARANCE OF COLLAGENASE-INDUCED EQUINE FORELIMB SUSPENSORY LIGAMENT DESMITIS

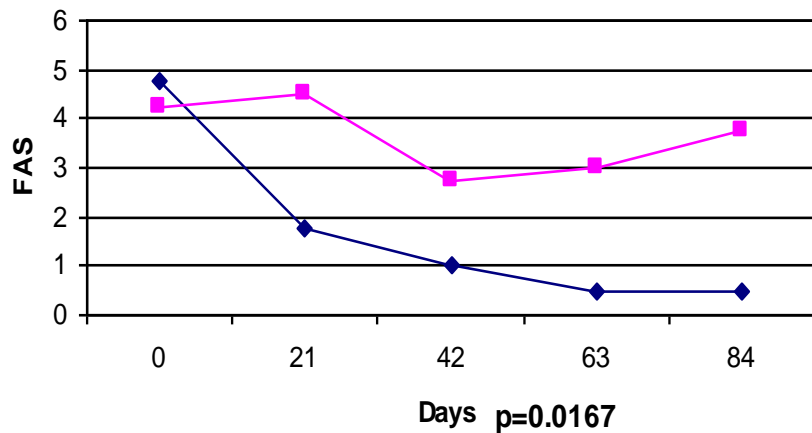
S. R. McCLURE,\*\* D. VANSICKLE,‡ R. EVANS,† E. L. REINERTSON\* and L. MORAN\*  
Departments of \*Veterinary Clinical Sciences; and †Veterinary Diagnostic and Production Animal Medicine, College of Veterinary Medicine, Iowa State University, Ames, IA, USA; and ‡Department of Basic Medical Sciences, School of Veterinary Medicine, Purdue University, West Lafayette, IN, USA



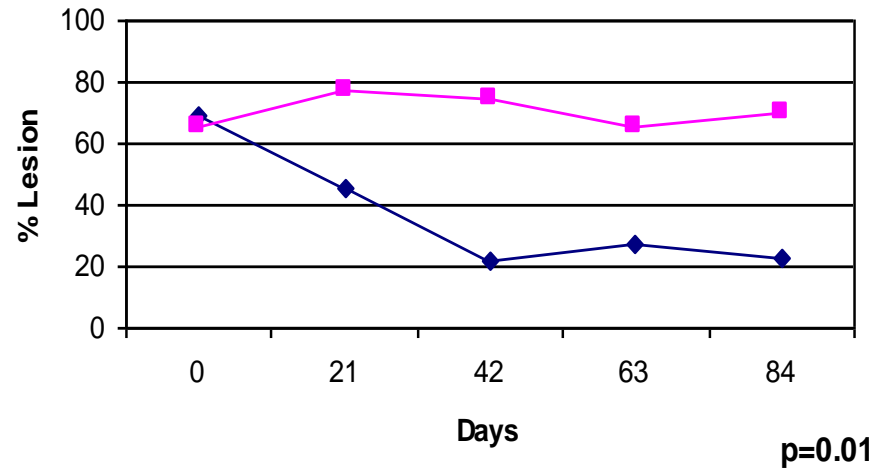
# Ultrasound Results

## Total of 5 Zones

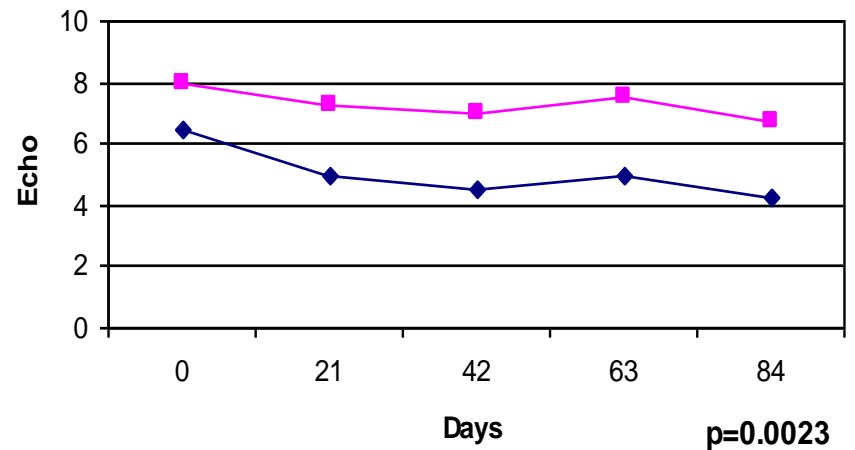
### Mean Total Fiber Alignment Score



### Mean Total %Lesion

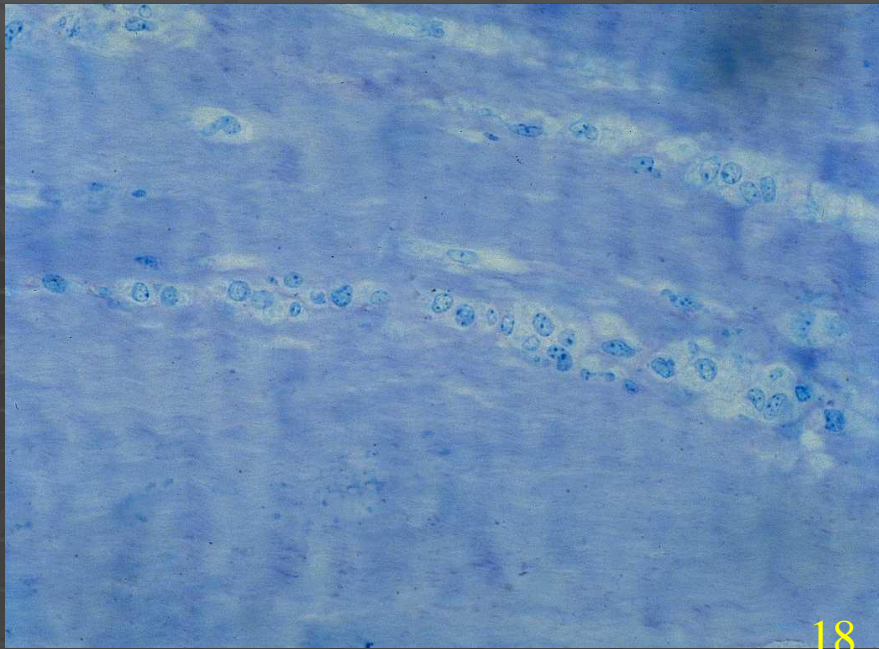


### Mean Total Echogenicity Score



Treated  
Control





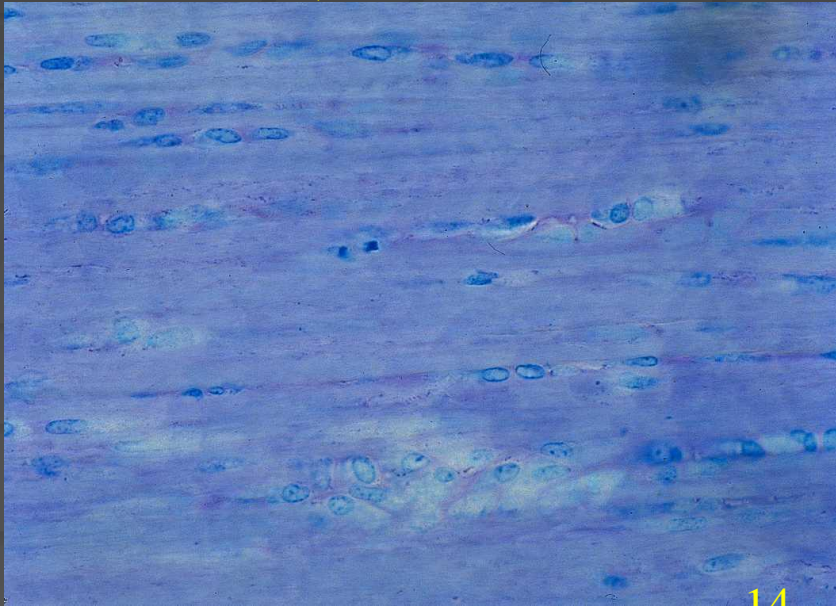
18

Treated, 50x



11

Control, 50x



14

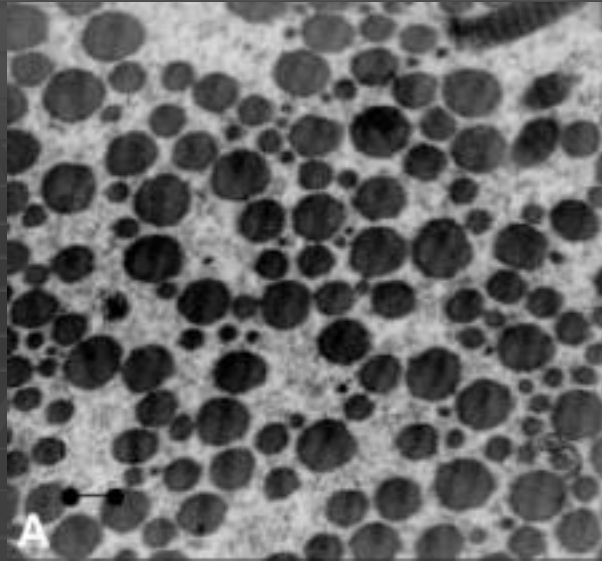
# Conclusion

- ESWT improved the rate of healing
- ESWT resulted in a stimulation of fibroblasts

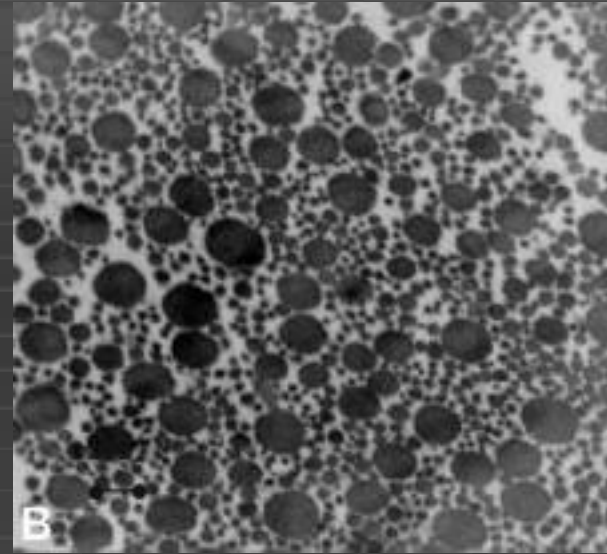
# **Ultrastructural and immunocytochemical evaluation of the effects of extracorporeal shock wave treatment in the hind limbs of horses with experimentally induced suspensory ligament desmitis**

Elisa H. Caminoto, DVM, MS; Ana Liz G. Alves, DVM, PhD; Renée L. Amorim, DVM, PhD; Armen Thomassian, DVM, PhD; Carlos A. Hussni, DVM, PhD; José Luis M. Nicoletti, DVM, PhD

- 10 horses
- Bilateral rear limb suspensory desmitis with collagenase
- 3 Tx @ 3 wk intervals with ESWT



Control



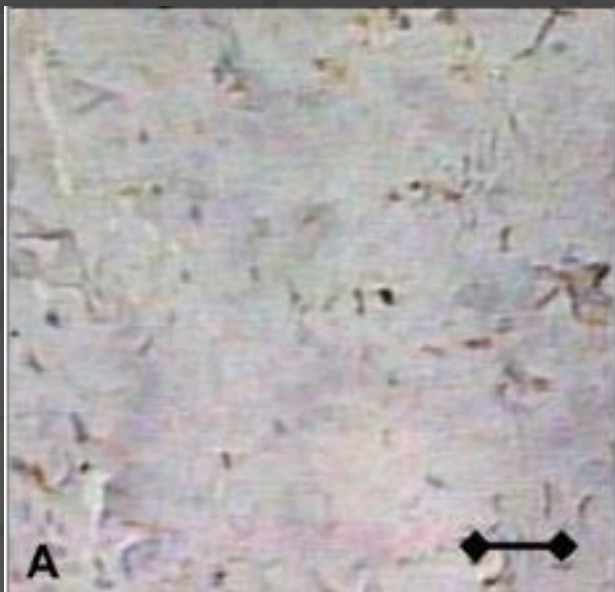
Treatment

- ESWT treated ligaments had smaller %Lesion from 6 weeks onward
- Greater number of small collagen fibrils @ 14 weeks

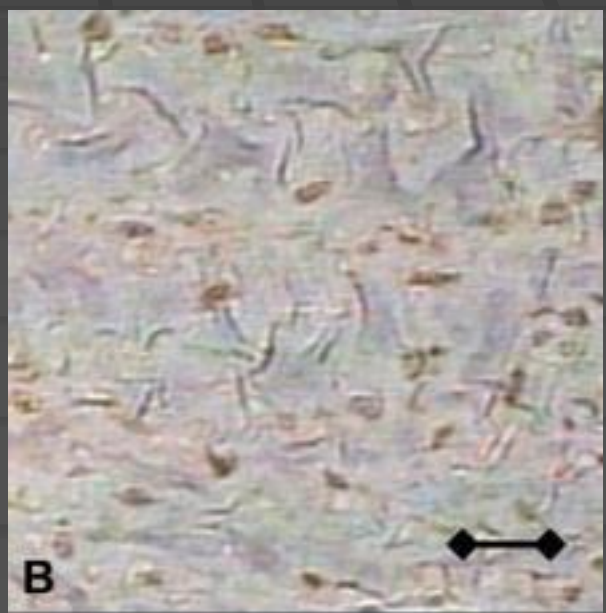


- Increased expression of TGFB-1 staining fibroblasts @ 14 weeks

Control



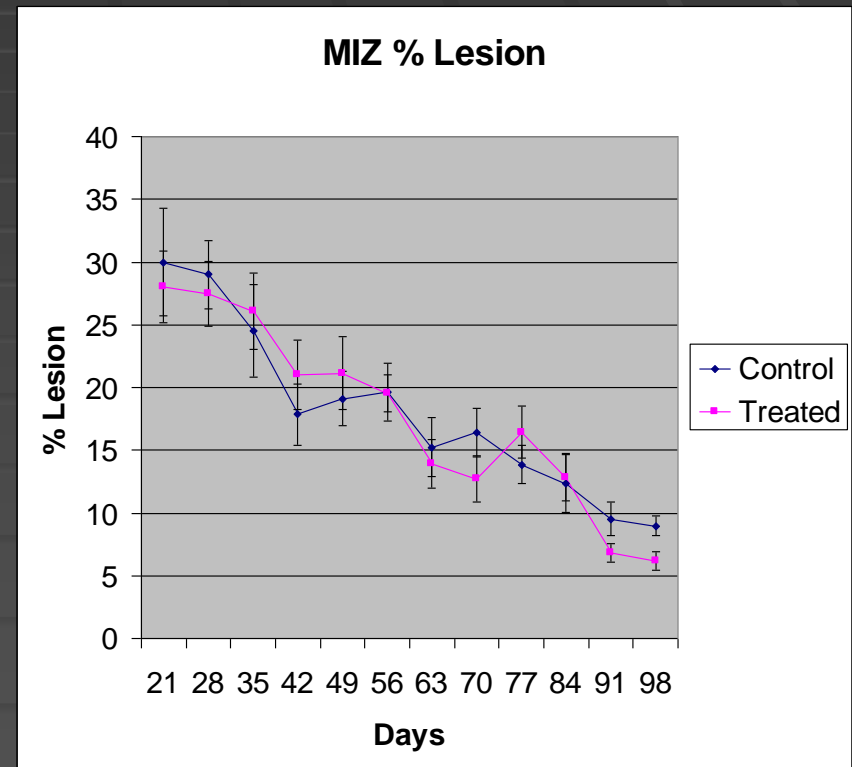
Treatment



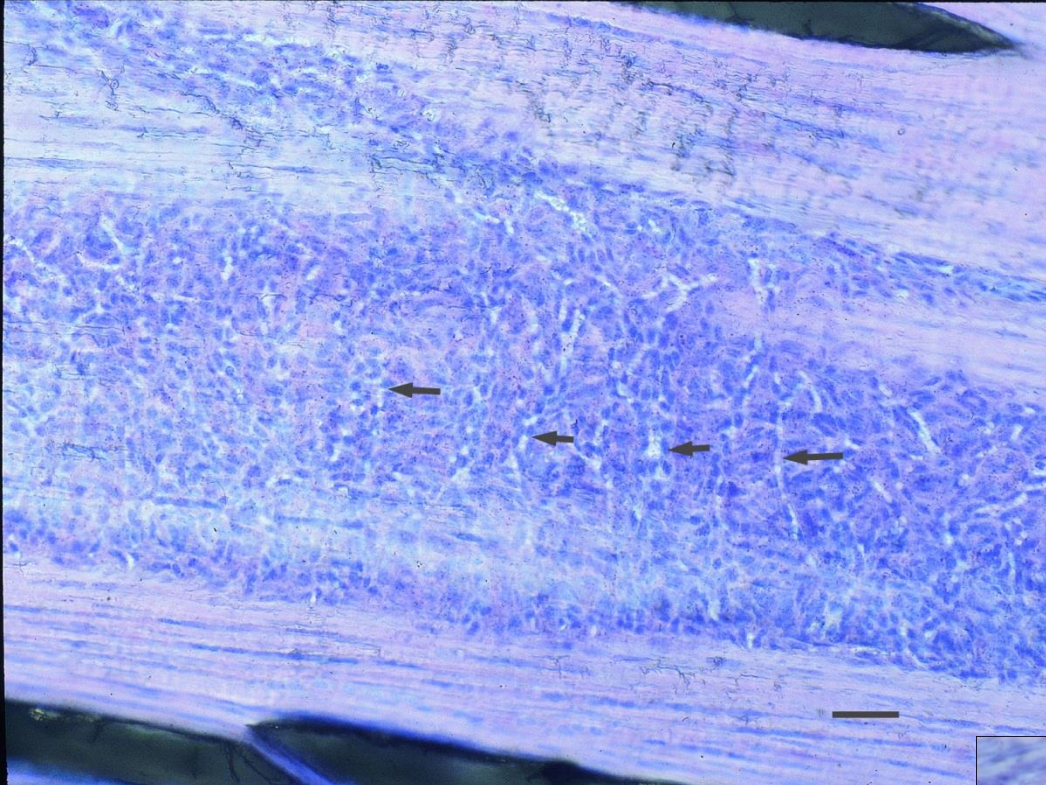
# The evaluation of extracorporeal shock wave therapy on collagenase induced superficial digital flexor tendonitis

K. D. Kersh<sup>1</sup>, S. R. McClure<sup>1</sup>, D. Van Sickle<sup>2</sup>, R. B. Evans<sup>3</sup>

- No significant changes for any of the 3 variables at MIZ or for sums

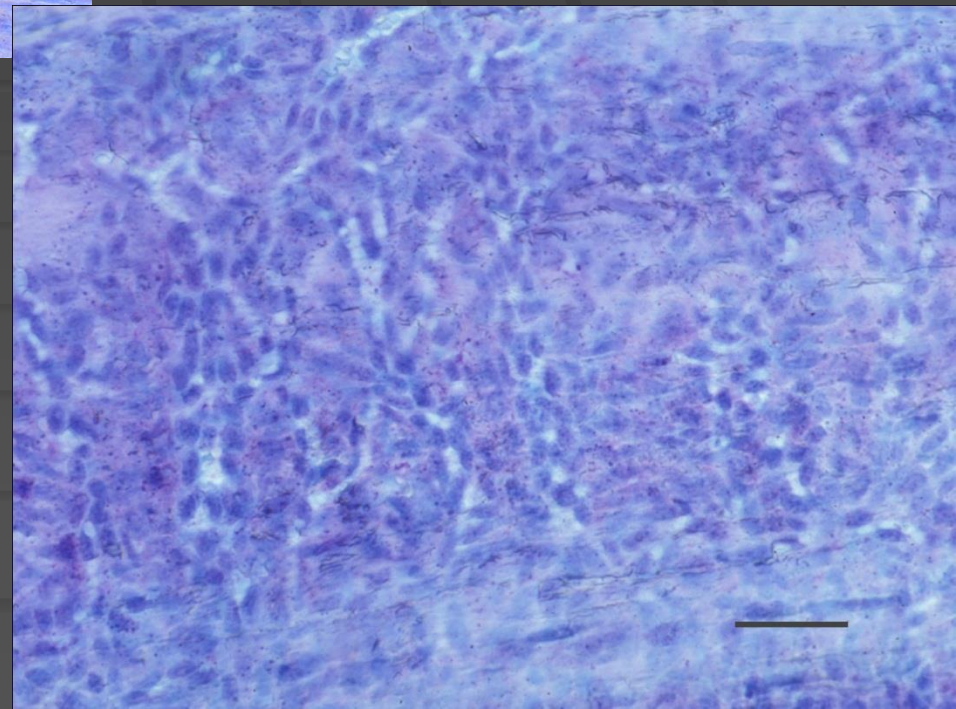


+/-SEM



■ ↑ Neovascularity of collagen bundles

$P < 0.001$





# Tendon – Ligament / Bone Interfaces

- Good to treat in all species

## The Effectiveness of Extracorporeal Shock Wave Therapy in Lower Limb Tendinopathy

### A Systematic Review

Sethu Mani-Babu,<sup>\*</sup> MBBS, Dylan Morrissey,<sup>\*†</sup> PhD, Charlotte Waugh,<sup>\*</sup> Hazel Screen,<sup>‡</sup> PhD, and Christian Barton,<sup>\*§||¶</sup> PhD

*Investigation performed at Queen Mary University of London, London, UK*

## Extracorporeal Shockwave Enhanced Regeneration of Fibrocartilage in a Delayed Tendon-Bone Insertion Repair Model

Dick Ho Kiu Chow,<sup>1</sup> Pui Kit Suen,<sup>1</sup> Le Huang,<sup>1</sup> Wing-Hoi Cheung,<sup>1</sup> Kwok-Sui Leung,<sup>1</sup> Chun Ng,<sup>2</sup> San Qiang Shi,<sup>2</sup> Margaret Wan Nar Wong,<sup>1</sup> Ling Qin<sup>1,3</sup>

## Extracorporeal Shockwave for Chronic Patellar Tendinopathy

Ching-Jen Wang,<sup>\*†</sup> MD, Jih-Yang Ko,<sup>†</sup> MD, Yi-Sheng Chan,<sup>‡</sup> MD, Lin-Hsiu Weng,<sup>†</sup> MD, and Shan-Lin Hsu,<sup>†</sup> MD  
*From the <sup>†</sup>Department of Orthopedic Surgery, Chang Gung Memorial Hospital, Chang Gung University College of Medicine, Kaohsiung, Taiwan, and the <sup>‡</sup>Department of Orthopedic Surgery, Chang Gung Memorial Hospital, Chang Gung University College of Medicine, Taoyuan, Taiwan*

## EFFECTS OF EXTRACORPOREAL SHOCK WAVE THERAPY ON FUNCTIONAL AND STRENGTH RECOVERY OF HANDGRIP IN PATIENTS AFFECTED BY EPICONDYLITIS

ANGELA NOTARNICOLA,<sup>\*†</sup> LIVIO QUAGLIARELLA,<sup>†</sup> NICOLA SASANELLI,<sup>†</sup> GIUSEPPE MACCAGNANO,<sup>†</sup> MARIA ROSARIA FRACELLA,<sup>†</sup> MARIA IMMACOLATA FORCIGNANÒ,<sup>†</sup> and BIAGIO MORETTI<sup>\*†</sup>

*\*Course on Motor and Sports Sciences, Faculty of Medicine and Surgery, University of Bari, Bari, Italy; and <sup>†</sup>Orthopedic Section, Department of Basic Medical Sciences, Neurosciences and Organs of Sense, Faculty of Medicine and Surgery, University of Bari, General Hospital, Bari, Italy*



# Shock Waves as a Component of Regenerative Medicine

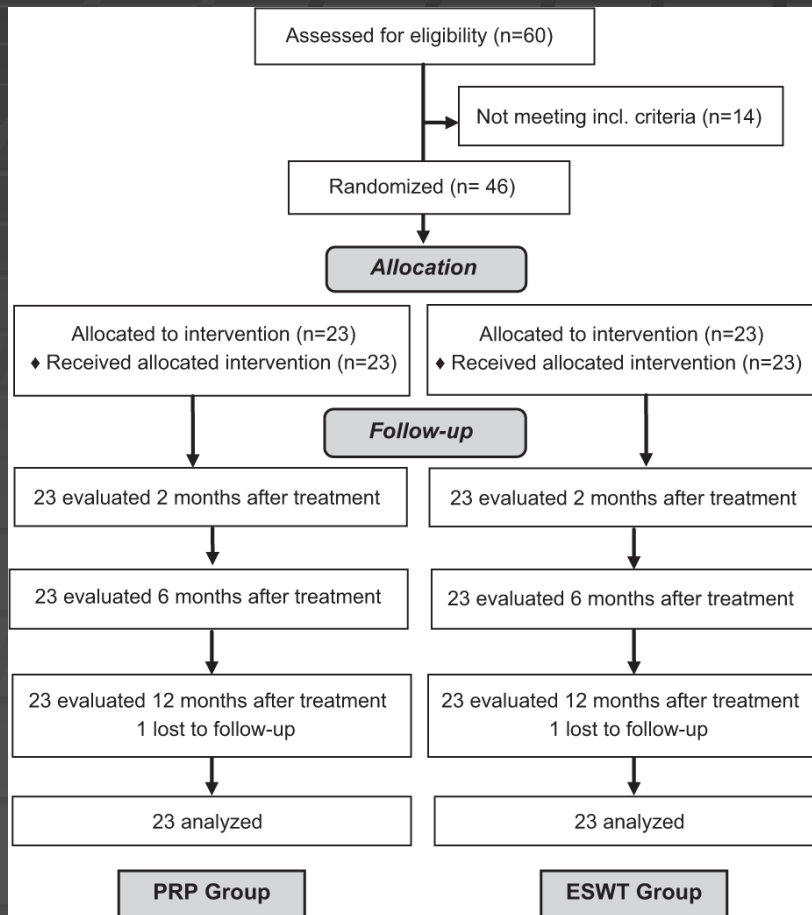
## ■ Regenerative therapy

How do we blend these together???

- Platelet rich plasma (PRP)
- Bisphosphonates
- Bone marrow derived stem cells
- Adipose derived stem cells
- **Shock wave**

# Platelet-Rich Plasma Versus Focused Shock Waves in the Treatment of Jumper's Knee in Athletes

Mario Vetrano,<sup>\*†</sup> MD, Anna Castorina,<sup>†</sup> MD, Maria Chiara Vulpiani,<sup>†</sup> MD, Rossella Baldini,<sup>‡</sup> PhD, Antonio Pavan,<sup>§</sup> MD, and Andrea Ferretti,<sup>||</sup> MD

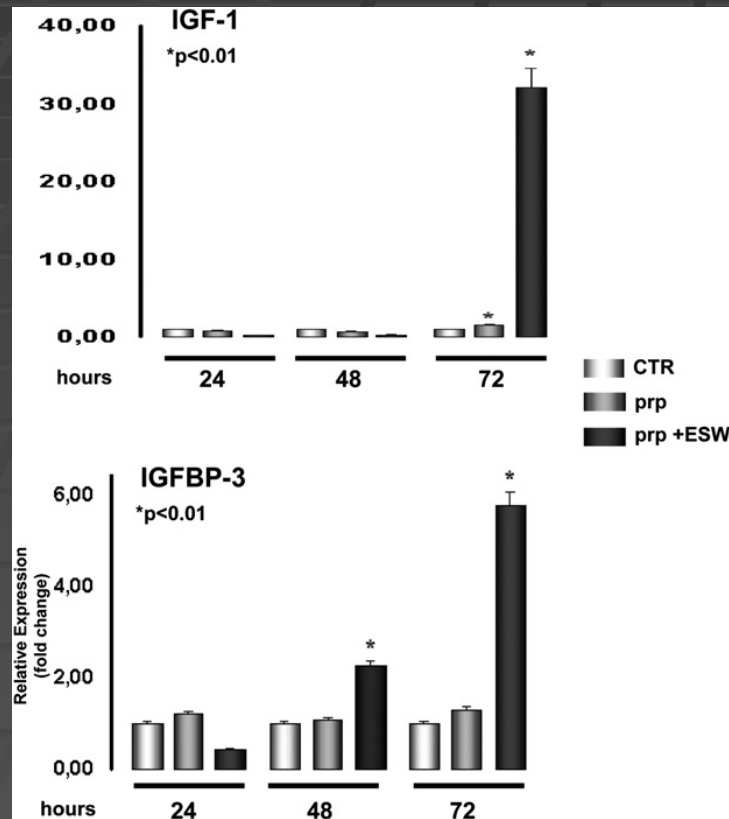


Both groups improved

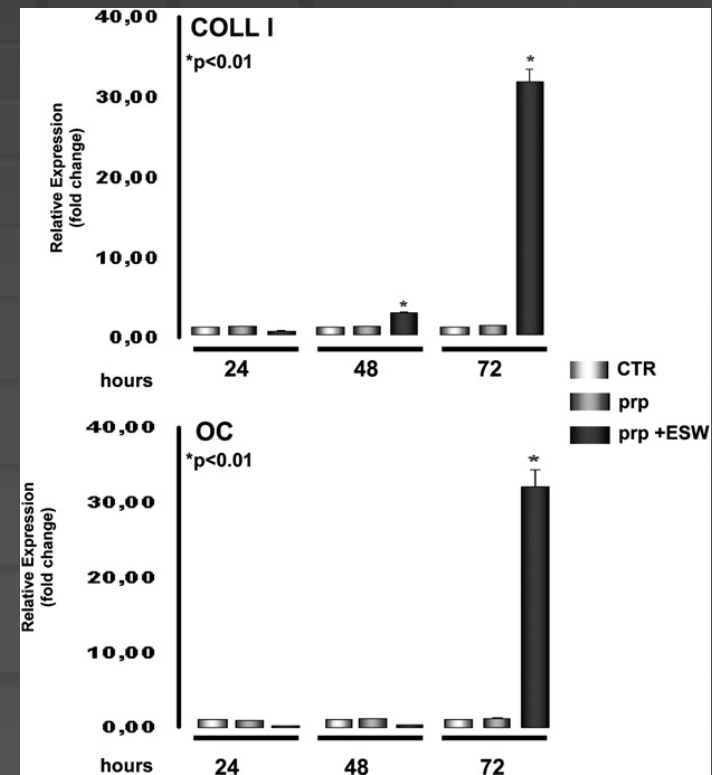
The PRP group improved more.

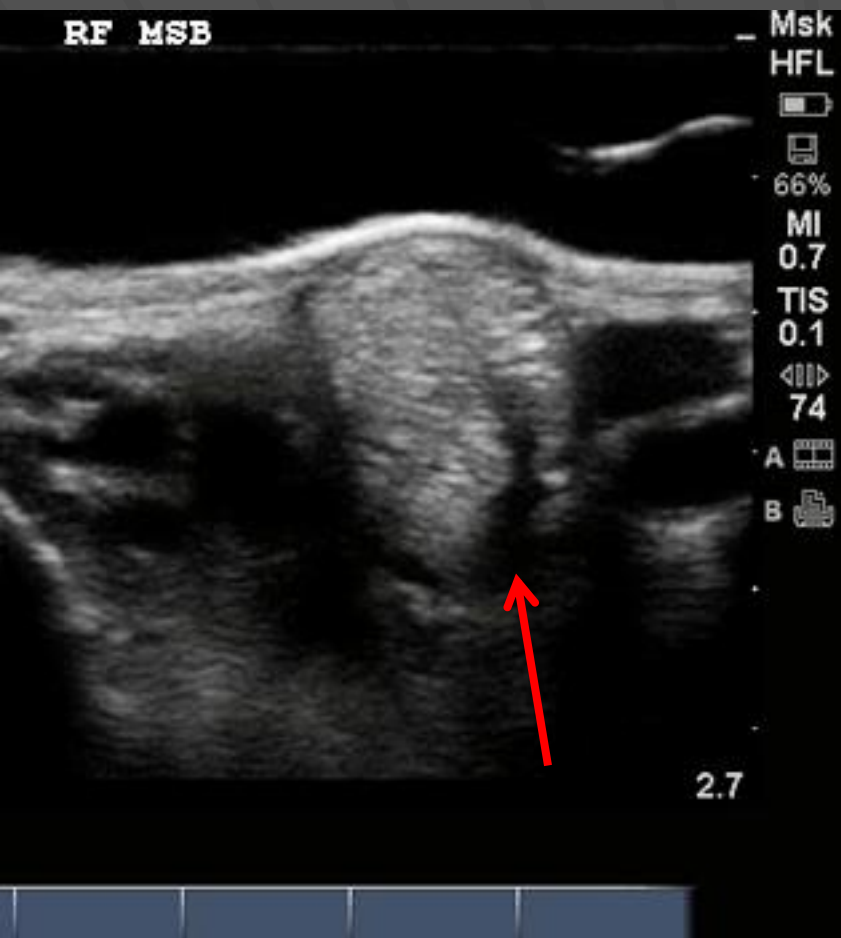
# EFFECT OF SHOCK WAVE TREATMENT ON PLATELET-RICH PLASMA ADDED TO OSTEOBLAST CULTURES

ANGELA NOTARNICOLA,<sup>\*a</sup> ROBERTO TAMMA,<sup>†a</sup> LORENZO MORETTI,<sup>\*</sup> ANTONIO PANELLA,<sup>\*</sup>  
 STEFANIA DELL'ENDICE,<sup>†</sup> ALBERTA ZALLONE,<sup>†</sup> and BIAGIO MORETTI<sup>\*†¶</sup>



Conclusion: It therefore seems possible that combining the two methods, ESWT procedures to infiltrate PRP and growth factors, could be a successful approach.





3 year TB filly

July  
PRP & Controlled Exercise

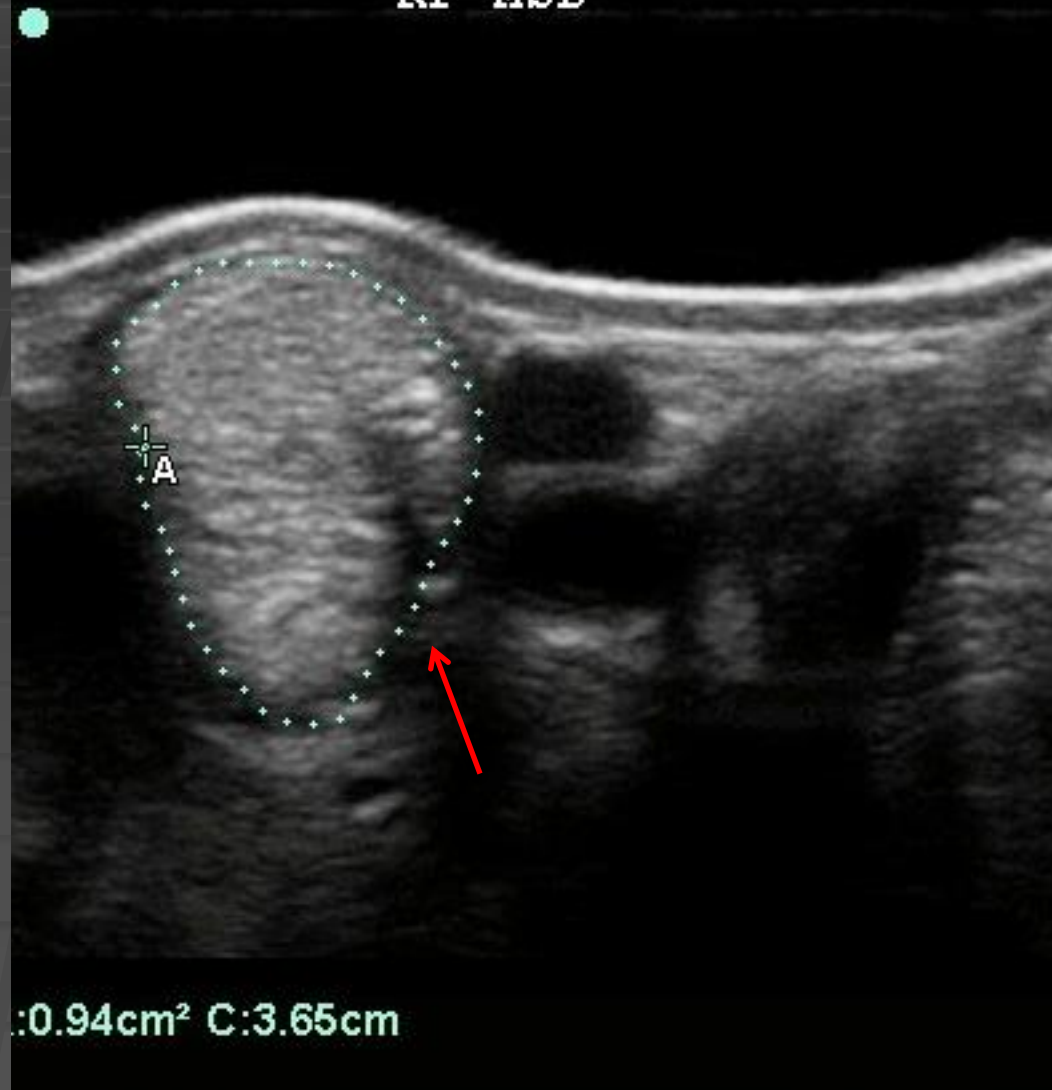


ERNON, LI.

306248

20

RF MSB



:0.94cm<sup>2</sup> C:3.65cm

September

ellipse

Manual

Delete



November, increased exercise to try to stimulate



January, limited healing, started ESWT



April



Res  
S MB

RF CMDACB  
12



Msk  
HFL  
88%  
MI  
0.8  
TIS  
0.1  
117  
A  
B

5 year Std Bred Gelding

November

Cine

Res  
S MB

RF CMDACB



Msk  
HFL  
85%  
MI  
0.7  
TIS  
0.1  
141  
A  
B

January

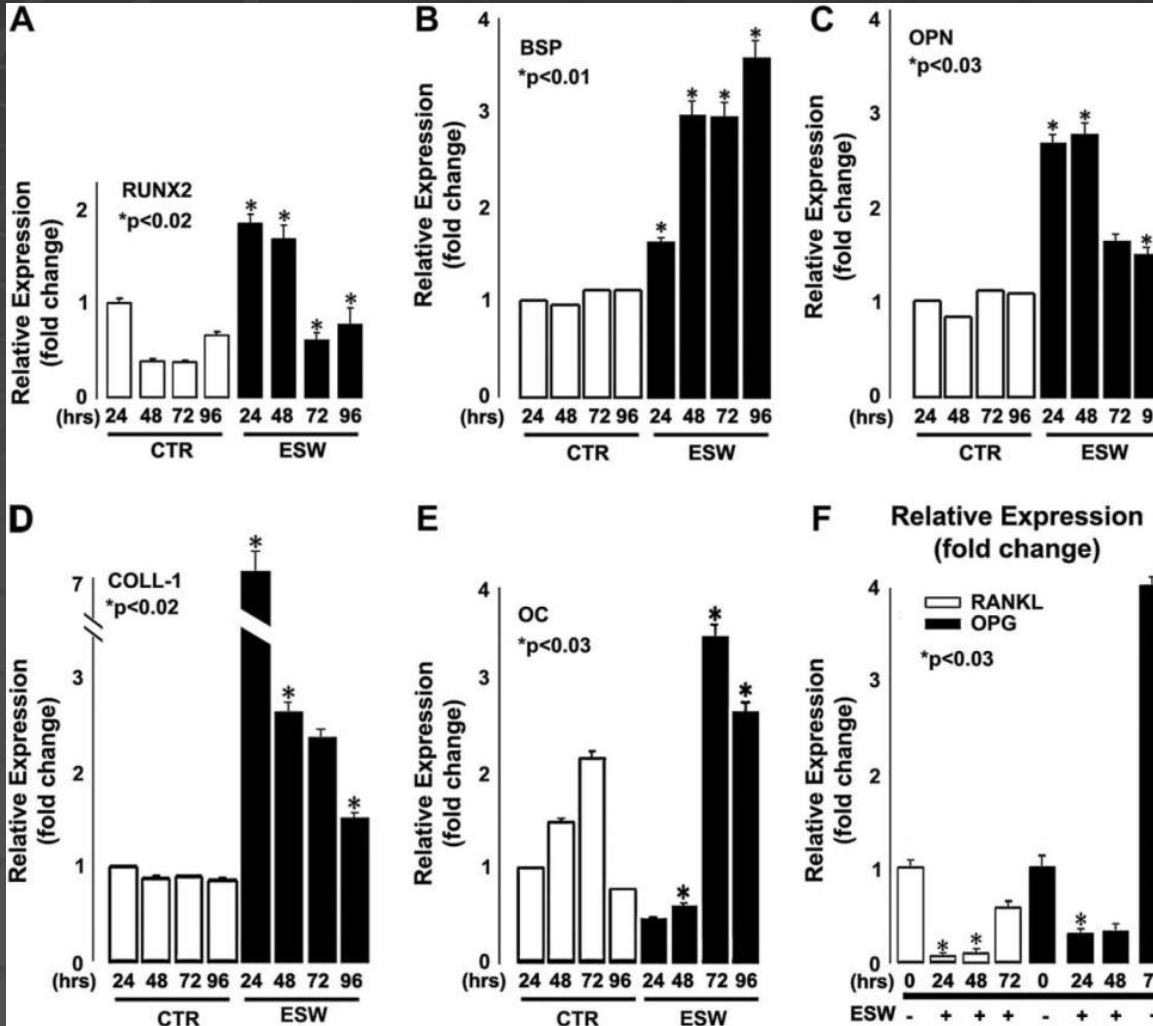
Cine

2.7

# EXTRACORPOREAL SHOCK WAVES STIMULATE OSTEOBLAST ACTIVITIES

ROBERTO TAMMA,\* STEFANIA DELL'ENDICE,\* ANGELA NOTARNICOLA,† LORENZO MORETTI,†  
SILVIO PATELLA,† VITTORIO PATELLA,† ALBERTA ZALLONE,\* and BIAGIO MORETTI †‡§

Department of Human Anatomy and Histology, † Department of Clinical Medicine, ‡ and Section of Tissue Engineering, §



Shockwaves induce bone healing through proliferation and differentiation of osteoblasts and reduction of pro-osteoclastogenic factors.

# Shock Wave Therapy on Equine Bone

INVITED REVIEW

## Effects of Extracorporeal Shock Wave Therapy on Bone

SCOTT R. MCCLURE, DVM, PhD, DAVID VAN SICKLE DVM, PhD, and M. RANDY WHITE, DVM, PhD

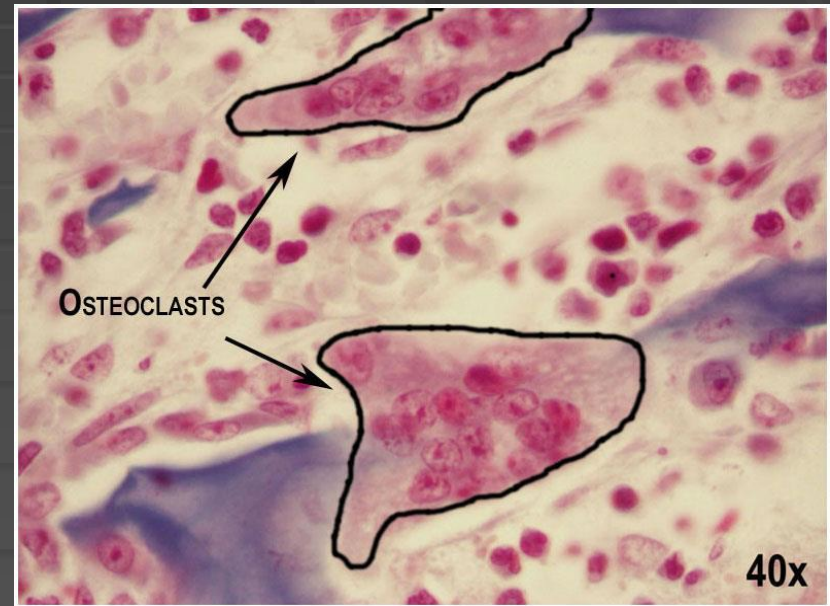
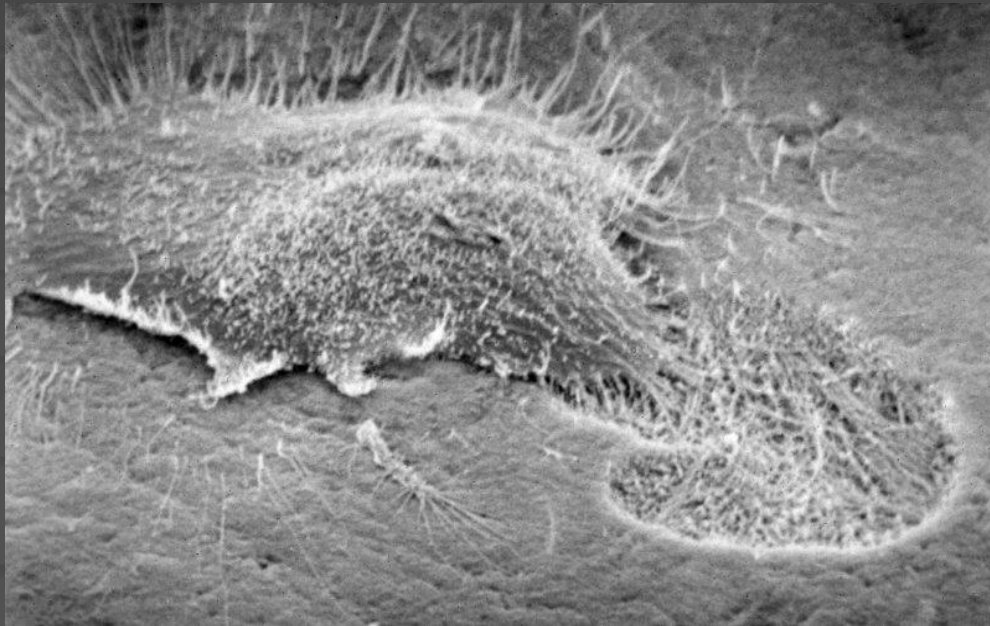


12.5x



# Bisphosphonates

- Prevention of osteopenia by induction of osteoclast apoptosis



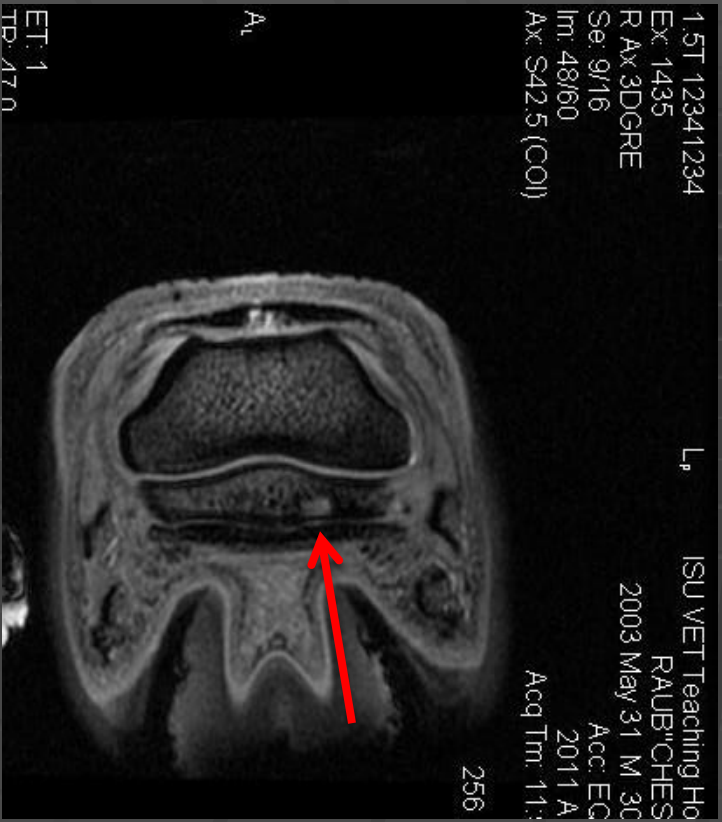
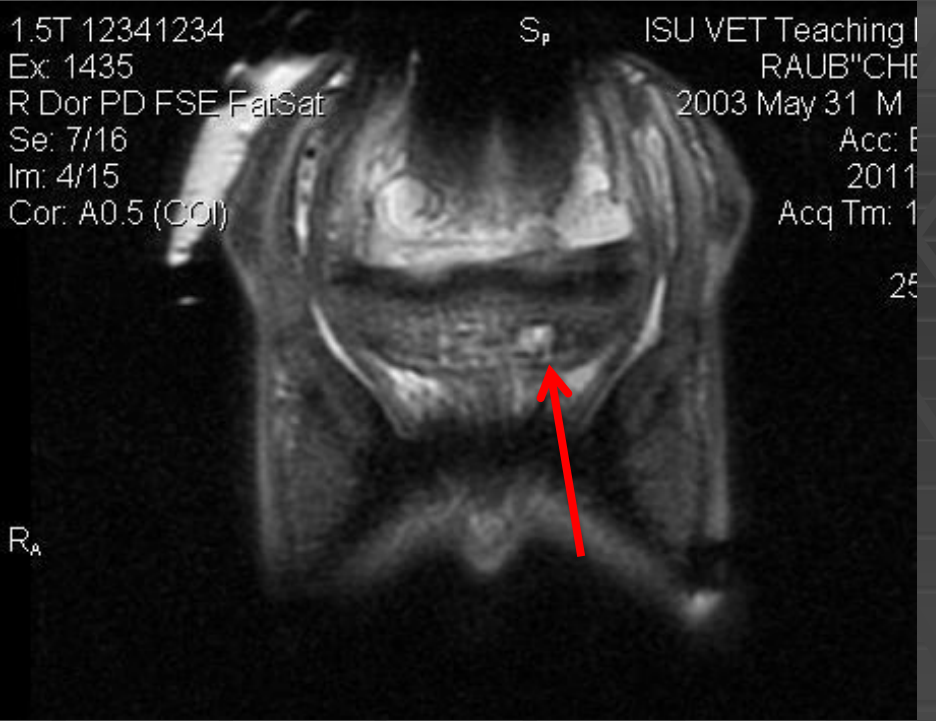


# Tiludronate

- Non-nitrogen containing compound
- Tildren®
- Methods of administration
  - IV bolus doses
  - CRI
  - IA







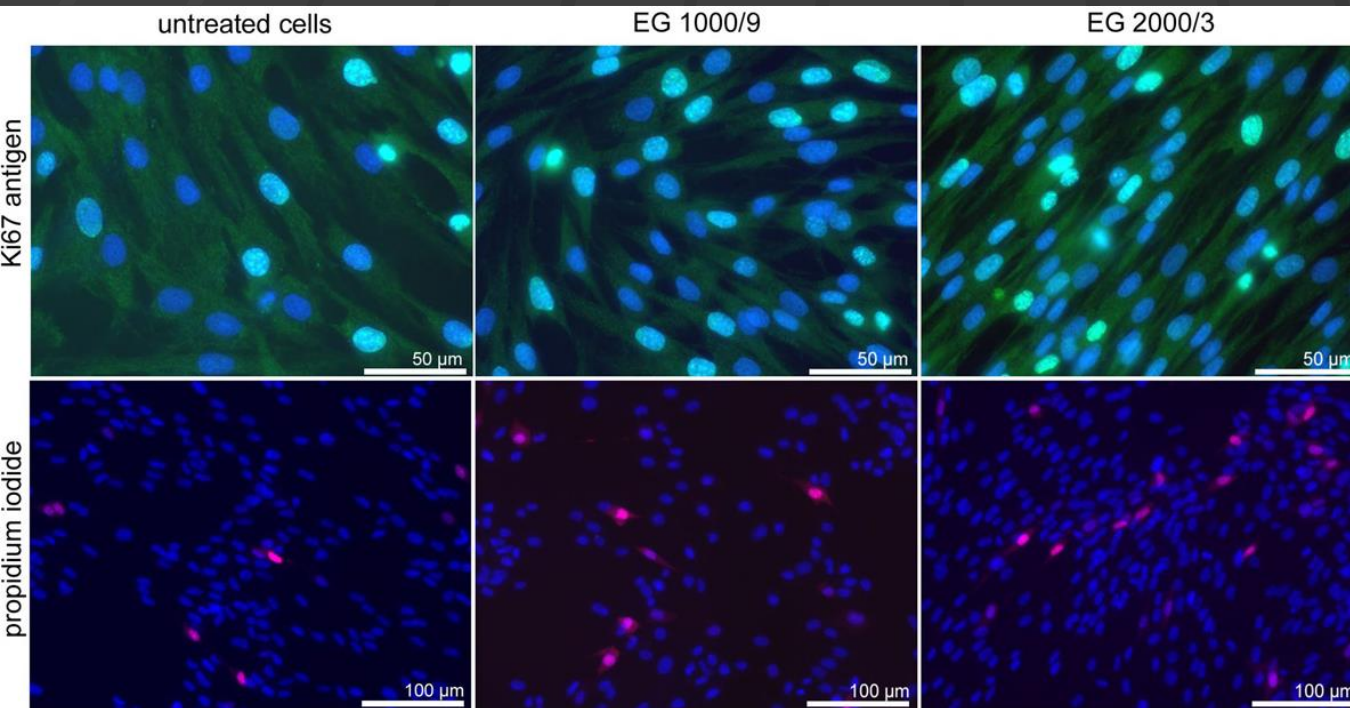
# Stem Cells and SWs

- Effect on Injected and Naturally Occurring MSCs

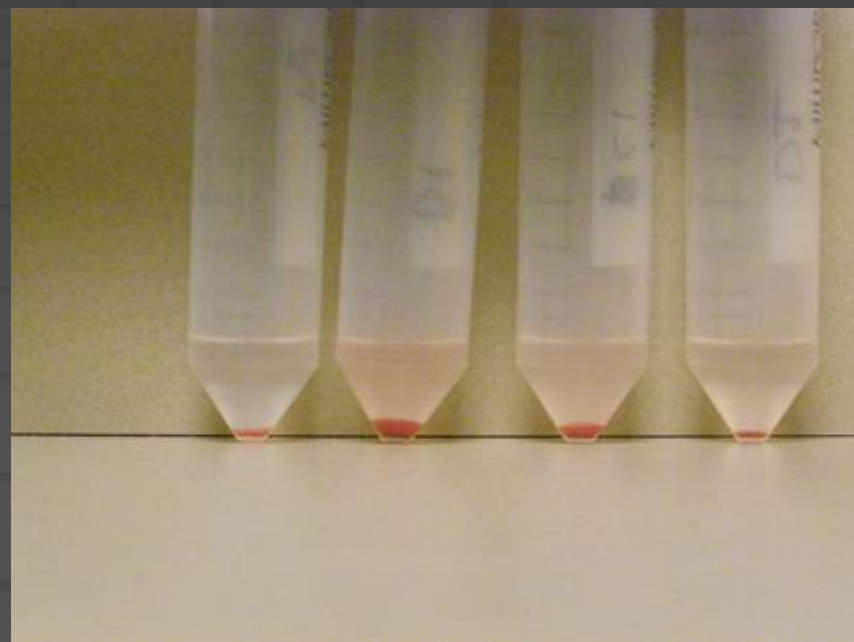
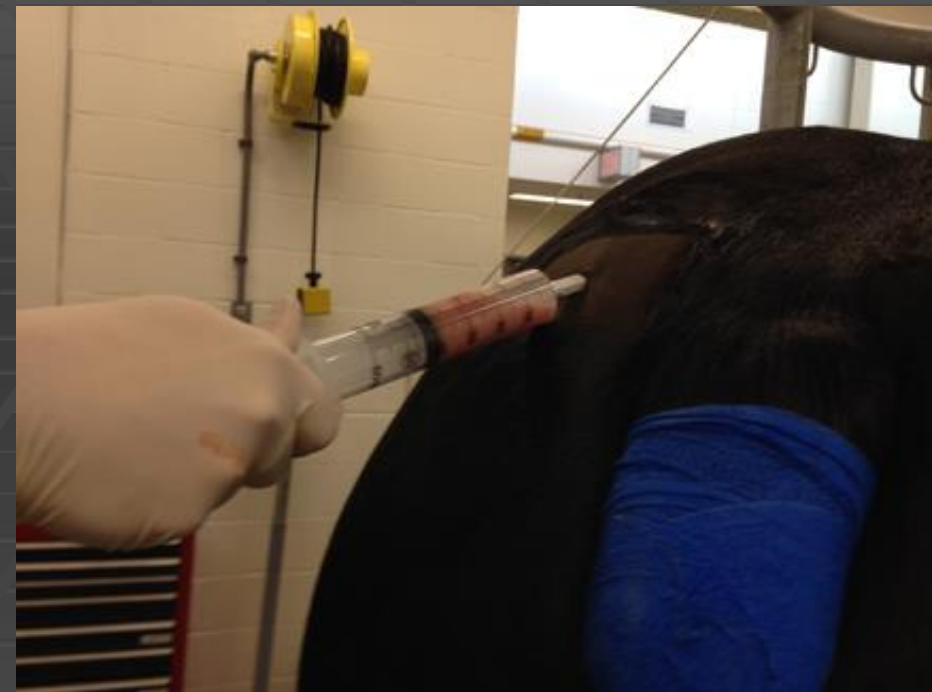


# Effect of extracorporeal shock wave on proliferation and differentiation of equine adipose tissue-derived mesenchymal stem cells in vitro

O Raabe<sup>1\*</sup>, K Shell<sup>1\*</sup>, A Goessl<sup>1</sup>, C Crispens<sup>1</sup>, Y Delhase<sup>2</sup>, A Eva<sup>3</sup>, G Scheiner-Bobis<sup>3</sup>, S Wenisch<sup>4</sup>, S Arnhold<sup>1</sup>



Conclusion: The present results show significant effects of shock waves on stem cells in vitro.



## Shockwave Stimulates Oxygen Radical-Mediated Osteogenesis of the Mesenchymal Cells From Human Umbilical Cord Blood

Feng-Sheng Wang,<sup>1</sup> Kuender D Yang,<sup>2</sup> Ching-Jen Wang,<sup>3</sup> Hui-Cheng Huang,<sup>1</sup> Chi-Chian Chio,<sup>1</sup> Te-Yao Hsu,<sup>4</sup> and Chia-Yu Ou<sup>4</sup>



## Extracorporeal shock wave promotes growth and differentiation of bone-marrow stromal cells towards osteoprogenitors associated with induction of TGF- $\beta$ 1

F. S. Wang, K. D. Yang, R. F. Chen, C. J. Wang, S. M. Sheen-Chen

STEM CELLS<sup>®</sup>

TISSUE-SPECIFIC STEM CELLS

## Shockwaves Induce Osteogenic Differentiation of Human Mesenchymal Stem Cells Through ATP Release and Activation of P2X7 Receptors

DAHUI SUN,<sup>a</sup> WOLFGANG G. JUNGER,<sup>b,c</sup> CHANGJI YUAN,<sup>d</sup> WENYAN ZHANG,<sup>e</sup> YI BAO,<sup>b</sup> DAMING QIN,<sup>a</sup> CHENGXUE WANG,<sup>a</sup> LEI TAN,<sup>a</sup> BAOCHANG QI,<sup>a</sup> DONG ZHU,<sup>a</sup> XIZHENG ZHANG,<sup>f</sup> TIECHENG YU<sup>a</sup>

These data indicate it is likely possible to administer multiple ESWT treatments to injuries also treated with MSCs without harming the repair response of transplanted MSCs and likely stimulating it.

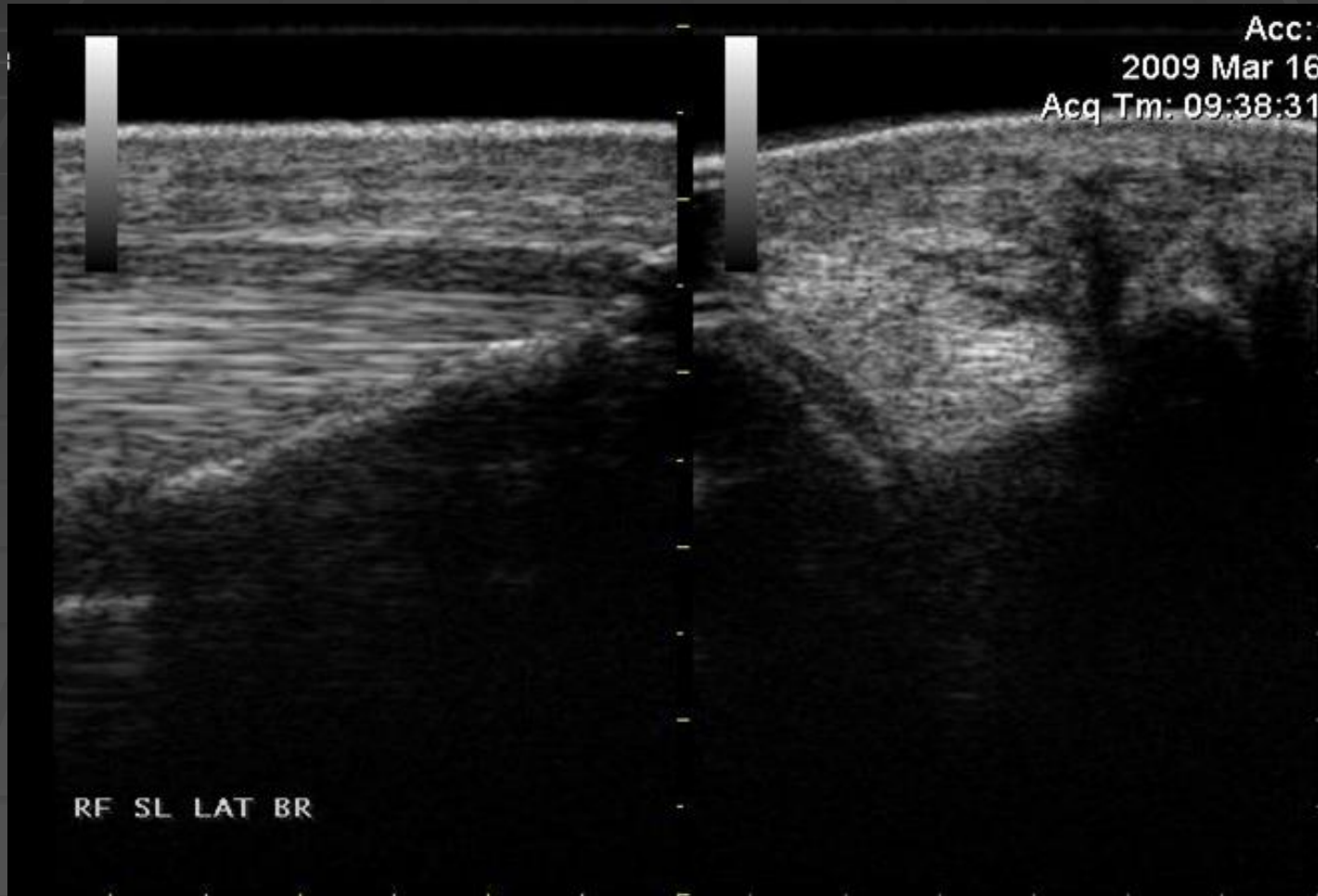
6 yr QH mare  
PRCA barrel racing



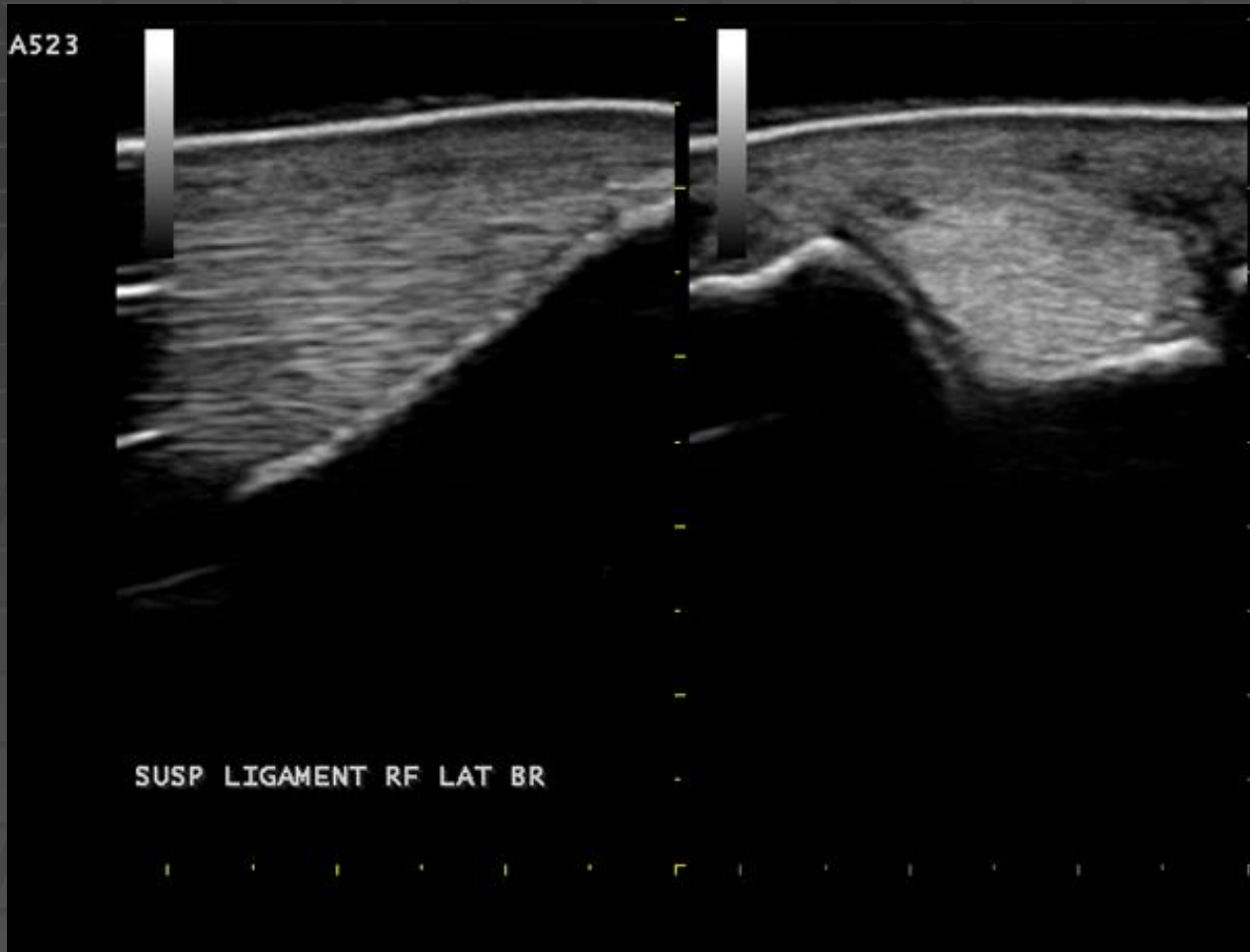
May 31

January 18

- 10 yr Pinto Mare
- Junior Jumper
- Adipose Derived MSCs and SWT







90 days

# Combinations of Biologics and Shockwaves

- Routinely performed

# Additional Applications

- Wounds
- Nonunions
- Septic implants
- Numerous other potential applications

# Case Report

## Shockwave therapy for treatment of a burn injury in a horse

J. E. Johnson, S. R. McClure\*† and C. C. Liskey‡



Fig 1: The dorsal (1a), right (1b) and left (1c) sides of the horse 11 days after the burn. The desiccated skin over the dorsum forms part of the eschar. The second and third degree burns on the left hip are devoid of eschar.





- Wounds of equine distal limb
  - Lack of soft tissue cover
  - Significant time to healing
  - Exuberant granulation tissue
  - Poor cosmetic outcome



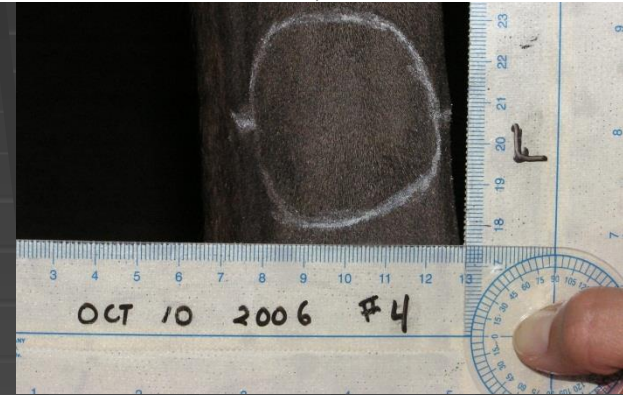


# Effects of extracorporeal shock wave therapy on wounds of the distal portion of the limbs in horses

Dean D. Morgan, DVM; Scott McClure, DVM, PhD, DACVS; Michael J. Yaeger, DVM, PhD;  
Jim Schumacher, DVM, MS, DACVS; Richard B. Evans, PhD

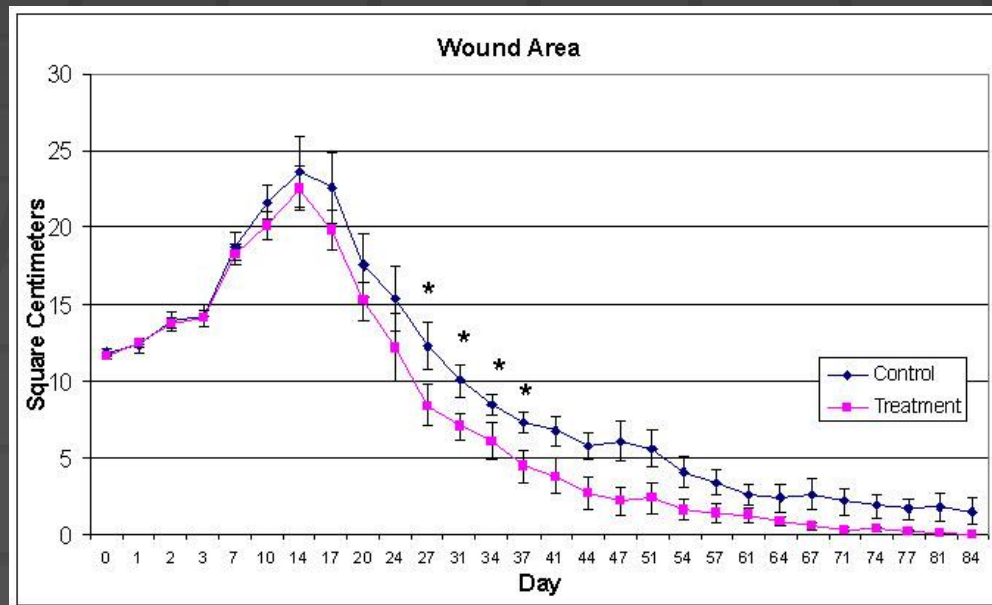
## Materials and Methods

- Six horses, 2-6 years old
- 5 cm diameter tattoo
  - Horizontal lines at center



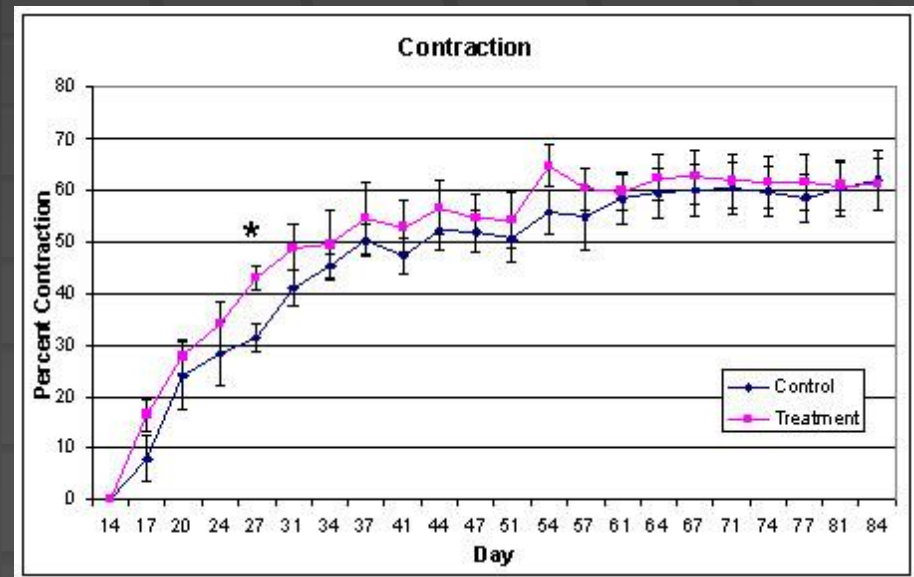
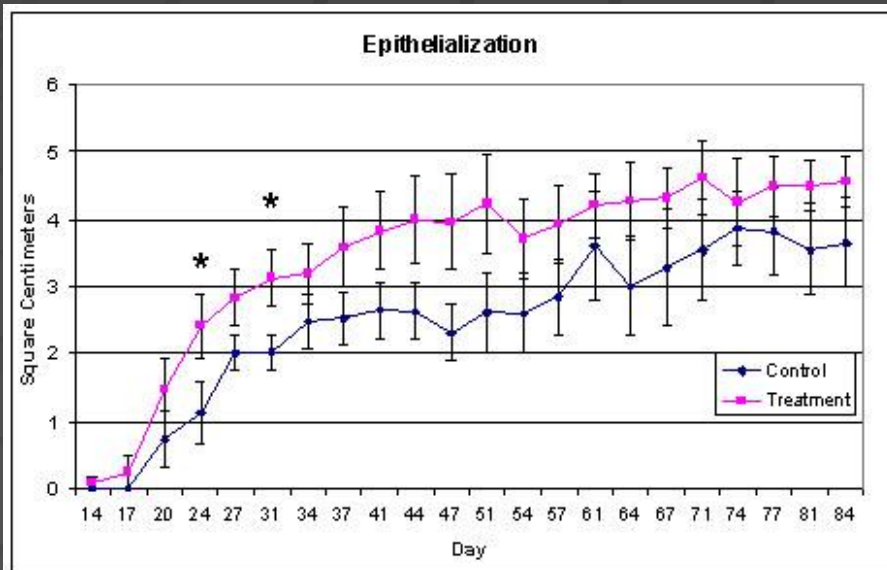
# Results

- Mean time to healing
  - Treated – 75.8 +/- 14.3 days
  - Control – 90.3 +/- 19.6 days
  - $P = 0.05$
- Wound area
  - Significant difference at days 27,31,34, and 37



# Results

- Epithelialization and Contraction
  - Epithelialization
    - Significant difference at days 24 and 31
  - Contraction
    - Significant difference at day 27 only



# Discussion

- Two week difference in time to healing
  - Contraction vs. Epithelialization
  - Growth factors
    - ESWT stimulates VEGF and TGF- $\beta$ 1

# **Effect of unfocused extracorporeal shock wave therapy on growth factor gene expression in wounds and intact skin of horses**

Kaitlyn A. Link; Judith B. Koenig, Dr vet med, DVSc; Andressa Silveira, DVM, DVSc;  
Brandon L. Plattner, DVM, PhD; Brandon N. Lillie, DVM, PhD

## **Effects of unfocused extracorporeal shock wave therapy on healing of wounds of the distal portion of the forelimb in horses**

Andressa Silveira, DVM; Judith B. Koenig, Dr med vet, DVSc; Luis G. Arroyo, DVM;  
Donald Trout, DVM, PhD; Noël M. M. Moens, DVM, MSc; Jonathan LaMarre, DVM, PhD;  
Andrew Brooks, DVM, PhD





DR3-030861  
WOLFSWINKEL-HENRY IM WARNING U

2797  
2009 11:59:17

Left Fore Fetlock Lateral

Se: 1/5

m: 1/2

ANKLE

112.6:1

d:DCM / Lin:DCM / Id:ID  
M:4096 L:2048

DR3 Portable Digital Imaging  
WOLFSWINKEL-HENRY IM WARNING U

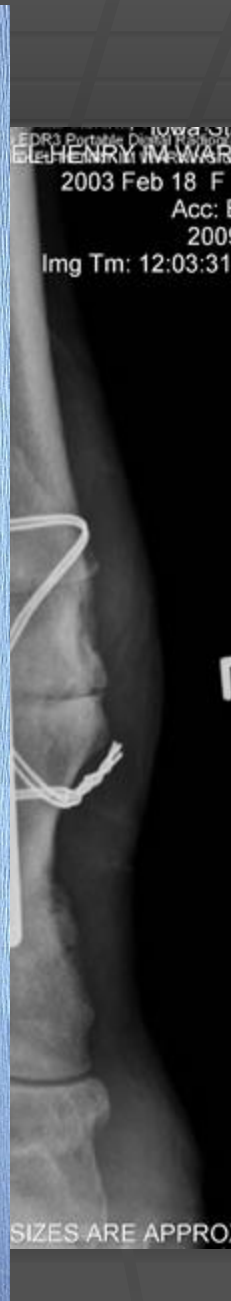
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Acc: E

2009

Img Tm: 12:03:31

SIZES ARE APPROX



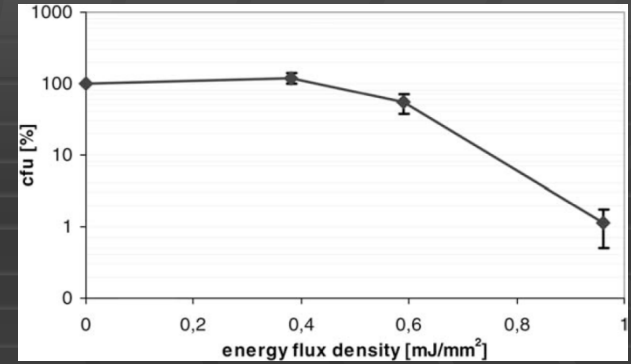


# ANTIBACTERIAL EFFECTS OF EXTRACORPOREAL SHOCK WAVES

LUDGER GERDESMEYER,\* CHRISTOF VON EIFF,<sup>†</sup> CARSTEN HORN,\* MARK HENNE,\*  
 MICHAELA ROESSNER,\* PETER DIEHL,\* and HANS GOLLWITZER\*<sup>‡</sup>

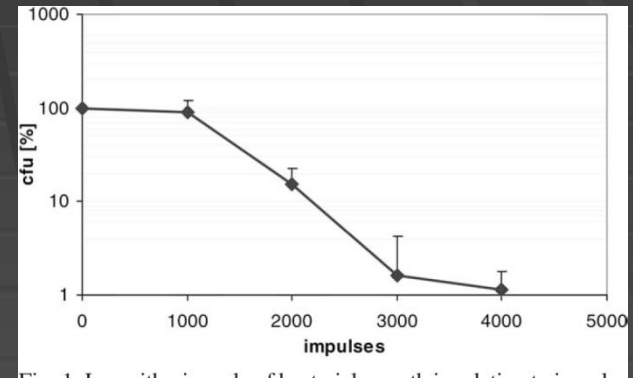
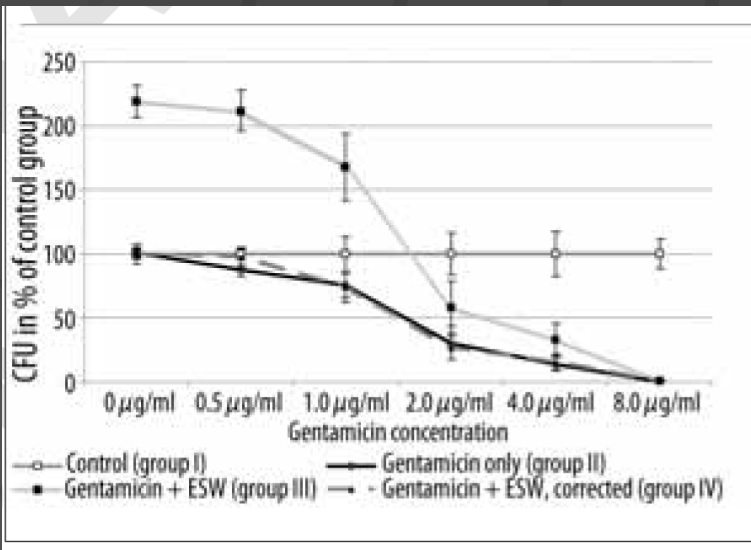
\*Klinik und Poliklinik für Orthopädie und Sportorthopädie der Technischen Universität München, München, Germany; and <sup>†</sup>Institut für Medizinische Mikrobiologie, Universitätsklinikum Muenster, Muenster, Germany

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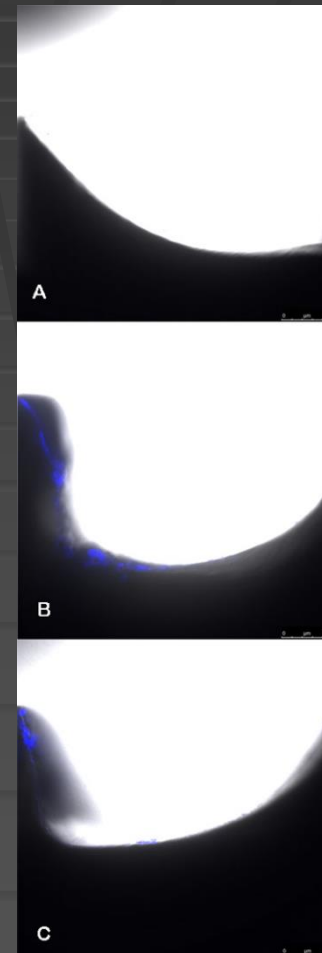
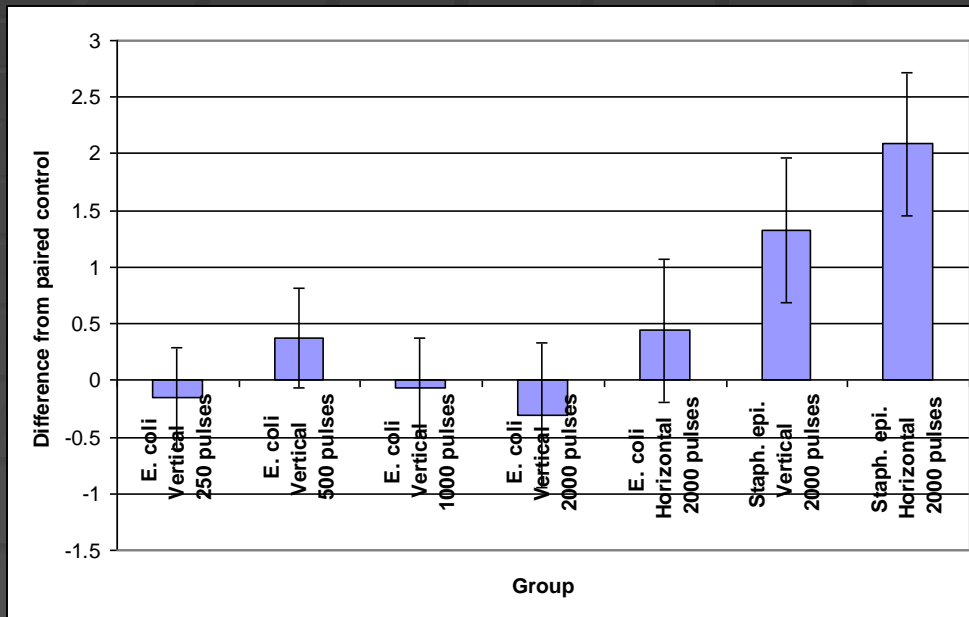
## Energy-dependent stimulatory and inhibitory effects of extracorporeal shock waves on bacteria and on gentamicin activity

Carsten Horn<sup>1AB CDEF</sup>, Ludger Gerdesmeyer<sup>2A DE G</sup>, Christof von Eiff<sup>3C DEF</sup>,  
 Reiner Gradinger<sup>1DE G</sup>, Hans Gollwitzer<sup>1A B C D E F G</sup>



# Absence of bactericidal effect of focused shock waves on an in-vitro biofilm model of an implant

Matthew S. Madron, Scott R. McClure, Ronald W. Griffith, Chong Wang



# Extracorporeal Shockwave Increases the Effectiveness of Systemic Antibiotic Treatment in Implant-Related Chronic Osteomyelitis: Experimental Study in a Rat Model

Mustafa Erkan Inanmaz,<sup>1</sup> Mustafa Uslu,<sup>2</sup> Cengiz Isik,<sup>3</sup> Ertugrul Kaya,<sup>4</sup> Tekin Tas,<sup>5</sup> Recep Bayram<sup>6</sup>

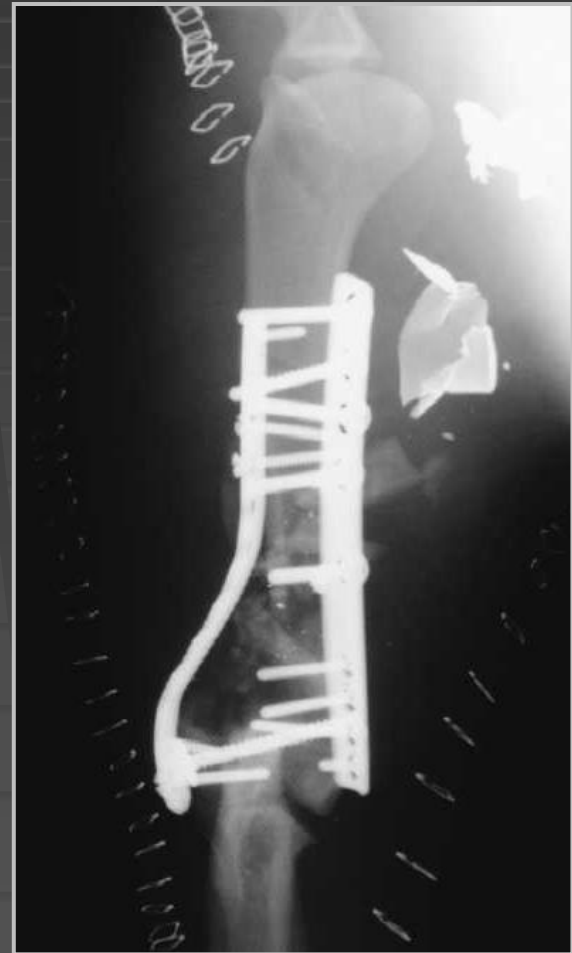
Groups	<i>n</i>	CFU/g ( $\times 10^5$ )	
		Mean	SD
Control	7	9.7	2.1
ESW	7	8.4	1.7
AB	8	6.0	1.4
ESW + AB	7	3.1	1.6

- Signalment
  - 6 year old MN Beagle cross
- History
  - Referred after sustaining gunshot injury to left foreleg
- Radiographs
  - Highly comminuted distal left humeral fracture

# “JOJO” - Preop



# “JOJO” - Immediate Postop





12 wks Post - Op  
(Pre ECSWT)



7 wks Post  
ECSWT



13 wks Post  
ECSWT





Thank you

