



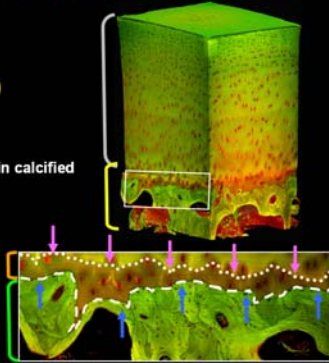
# Changes in Hydraulic Conductance of Human Subchondral Bone Plate with Progression of Osteoarthritis

Jennifer Hwang; Won C Bae; Wendy Shieu; Chad W Lewis;  
William D Bugbee, MD; Robert L Sah, MD, ScD  
Department of Bioengineering & Whitaker Institute of Biomedical Engineering  
University of California-San Diego, La Jolla, CA



## The Osteochondral Interface

- uncalcified cartilage
  - avascular, multiphasic [1]
- subchondral bone plate (ScBP)
  - calcification front [2-4]
- tidemark
  - calcification front [2-4]
- calcified cartilage (CC)
  - hypertrophic chondrocytes in calcified matrix [5]
  - vascular [2, 6-8]
- cement line
  - ossification front [2-4]
- bone
  - porous, vascular [9,10]



## Osteoarthritic Changes at the Osteochondral Interface

tissue	composition				structure		
	cellularity	matrix	vascularity	fractures	thickness	permeability	gross appearance
cartilage	↓	↓	×	↑	↓	↑	fibrillated
CC	?	↑	↑	↑	↑	?	2+ tidemarks
bone	↑	↓	↑	↑	↑	?	sclerotic

## Hypothesis

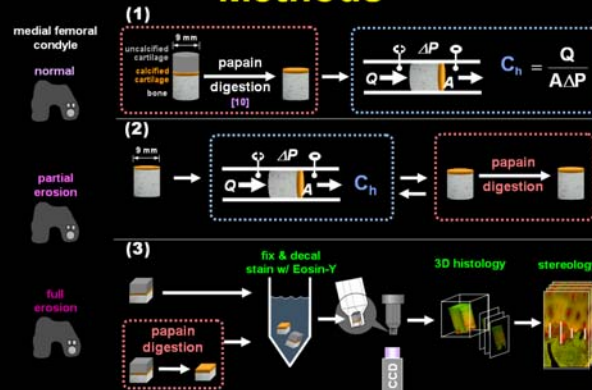
Hydraulic conductance ( $C_h$ ) of ScBP increases with structural changes that occur with the progression of osteoarthritis (OA).

## Objectives

For the human medial femoral condyle,

- Determine  $C_h$  of ScBP for different grades of OA erosion
- Evaluate contribution of residual cartilage on  $C_h$  of eburnated ScBP
- Evaluate thickness and vascularity of CC and ScBP for different grades of OA erosion as structural determinants of  $C_h$

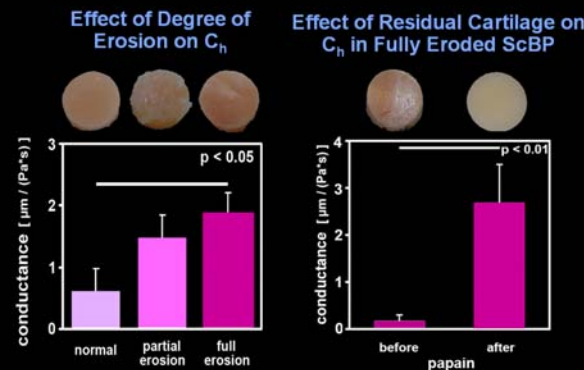
## Methods



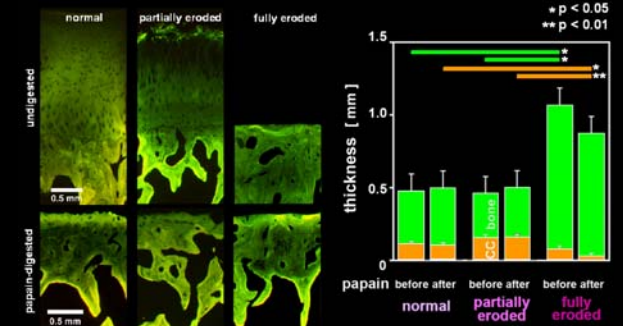
## Statistics

- mean ± SEM
- Exp 1: effect of erosion (non, partial, full) on  $C_h$ 
  - ANOVA
  - Tukey post-hoc
- Exp 2: effect of papain digest on  $C_h$  in eburnated ScBP
  - repeated measures ANOVA
- Exp 3: thickness and vascularity of ScBP
  - repeated measures ANOVA
    - factor: erosion (non, partial, full)
    - repeated: with, without digestion
  - Tukey post-hoc

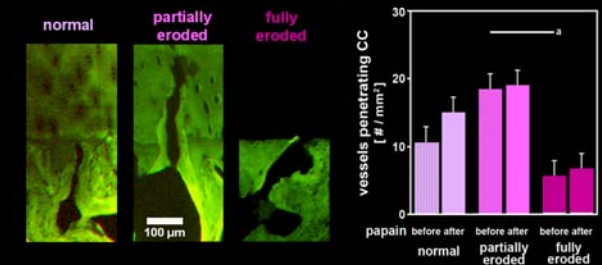
## Results



## Thickness of CC and ScBP



## Vascularity of CC



## Discussion

### Biomechanical Effects of Altered ScBP Conductance

- fluid exudation from tissue during joint loading
  - overlying cartilage
  - opposing cartilage
- fluid depressurization
- high tissue strains

### Structural Basis for ScBP Conductance

- Residual cartilaginous pockets in fully eroded bone [11-13]
  - ↑ conductance may be due to several distinct structural changes at different stages of OA
    - vascularity
    - erosion of CC layer

## References

- Maroudas+, *Nature* 219(5160):1260-1, 1968.
- Green+, *Arch Pathol* 90(2):151-8, 1970.
- Bullough, *OAC* 12 Suppl A:S2-9, 2004.
- Oegema+, *Microsc Res Tech* 37:324, 1997.
- Hunziker+, *OAC* 10(7):564-72, 2002.
- Holmdahl+, *Acta Orthop Scand* 20(2):156-65, 1950.
- Lane+, *JBJS* 59(3):272-8, 1977.
- Barrie+, *J Rheumatol* 13(6):1099-104, 1986.
- Hayes+, in *Basic Orthopaedic Biomechanics*, Mow+, Eds. 69-111, 1997.
- Clark+, *JBJS* 72(5):866-73, 1990.
- Meacham+ *J Pathol* 102(1):1-8, 1970.
- Mankin *N Engl J Med* 291(25):1335-40, 1974.

## Acknowledgments

NIH, NSF, MTF