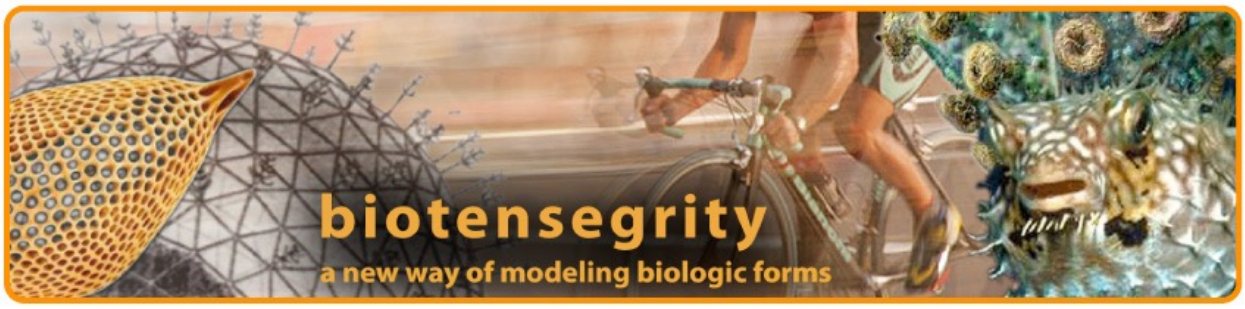


Rawhide

AS AN ORTHOPEDIC SURGEON, I spent years working with live tissues at their most intimate level. Tissues at the operating table are remarkably different than tissues at an anatomy-dissecting table, or even at autopsy of the very recently deceased. Ask any surgeon, muscles are soft and mushy and easily separated and torn with just some moderate finger manipulation, and the same is true of the connective tissue. The ligaments and tendons are tougher, but they are also quite soft. Articular cartilage is soft and friable, easily dented with slight pressure and easily torn with fingernail pressure; it has the feel and friability of the white of a hardboiled egg. Cancellous bone is soft and easily crushable, like eggshells, and bones are springy and bendable. In children, you can easily demonstrate the springiness at the operating table, and even in adults, it is possible to test the springiness of the radius during clinical examination. None of these qualities of softness and 'liveliness' are apparent after death; the tissues then become stiff and tough, the bones hard and brittle. Why the disparities between live and dead tissues?

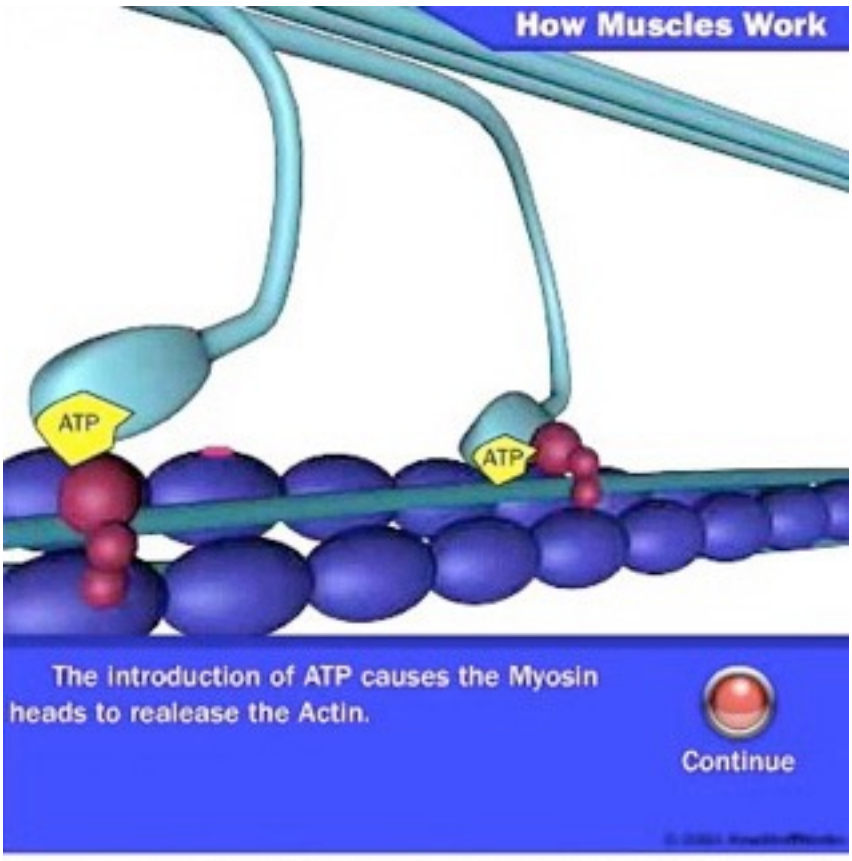
We know what happens in soft tissue, we are just not paying attention. It starts at the instant of death and, within a few hours after a person or animal dies, the joints of the body stiffen and become locked in place. This stiffening, well known to all who follow the crime lab TV programs, is *rigor mortis*. *Rigor mortis* begins immediately with death, takes a few hours to complete, and lasts until the tissues putrefy. Depending on temperature and other conditions, that would take about 72 hours. The skeletal muscles partially contracting cause the phenomenon. The muscles are unable to relax, so the joints become fixed in place, and will remain so, until the tissues putrefy.

More specifically, what happens is that the membranes of muscle cells become more permeable to calcium ions. Living muscle cells expend energy to transport calcium ions to the outside of the cells. The calcium ions that flow into the muscle cells promote the cross-bridge attachment between actin and myosin, two types of fibers that work together in muscle contraction. The muscle fibers ratchet shorter and shorter until

they are fully contracted or as long as the neurotransmitter acetylcholine and the energy molecule adenosine triphosphate (ATP) are present.

From: **http://health.howstuffworks.com/muscle2.htm**

However, **muscles need ATP** in order to release from a contracted state (it is used to pump the calcium out of the cells so the fibers can unlatch from each other). ATP reserves are quickly exhausted from the muscle contraction and other cellular processes. This means that the actin and myosin fibers will remain linked until the muscles themselves start to decompose.



Muscles create force by cycling myosin crossbridges.

If decomposition is prevented, the stiffness will remain. If allowed to rot, the joints are stiff for 1-3 days, but after this time general tissue decay, and leaking of lysosomal intracellular digestive enzymes will cause the muscles to relax. This would soon create a stinking mess, intolerable in laboratory testing conditions.

The muscles not only stiffen, the skin and connective tissue, including the collagen matrix of bone, are the makings of leather. If the collagen dries out it becomes rawhide, a stiff leather that when wetted, will start to putrefy again. The collagen can be treated by aldehydes, like formaldehyde, that makes it leather that is water tolerant, and bone or cartilage from embalmed bodies will have leather souls, (sorry, I couldn't

help myself). Boiling leather will initially soften it, but then it shrinks and becomes very stiff. Boiled leather that stiffened was actually used as amour by the knights of olde, so, if you boil bones to clean off the tissues, the collagen matrix of the bone and cartilage becomes very stiff and hard, like dried out soup bones. In any case, any method to keep the collagen in bone and cartilage from putrefying creates leather that stiffens, and binds the dead bone and cartilage into rigid structures, unlike anything encountered by the surgeon.

In the laboratory, cartilage and bone are always processed in some way. If they are just frozen, as soon as they are thawed they start to putrefy, unless the collagen has become dry and rawhide-like. Kept in a laboratory freezer, within the interstices of bone, collagen will dry out, and it would require soaking the bone in water for a period to rehydrate it. Just spraying the bone with water, a method often used in laboratories to keep the tissues 'life-like', will not do. If it is not stinking, leather-bound cartilage and bone are being tested in a state far different than live tissue. As muscle begins to deteriorate immediately after death, it is really close to impossible to test the tensional strength of muscle and tendons, as it would have to be performed on live subjects.

When evaluating any reports on bone, cartilage, muscle, tendons, ligaments, or other fascial tissue, it must be clear as to how long after death the tissue was harvested, and how it was handled post mortem. The tone of tissues changes instantly after death, and become less and less life-like with time, and the methods used to keep the tissues from putrefying, including freezing fresh kill, may not be much help in preserving a 'natural state'. Researchers, and those of us who rely on their research for some understanding of tissue function, must be aware of the changes that occur with death that would alter the tissue mechanics. During my reading of the literature, there does seem to be a limited awareness that post mortem handling of the tissues might make a difference. Here are quotes from research articles on how they handled bone before testing. These are typical, the first three found on a random search:

"Bone Specimens
Cortical bone specimens were obtained from the midshafts of human femora from three males (63, 72, and 74 years old) and two females (71 and 83 years old). These bones were stored at -20°C until the time of testing."

Shear Strength and Fatigue Properties of Human Cortical Bone
Determined from Pure Shear Tests
C. H. Turner,1 T. Wang,1 D. B. Burr2
Calcif Tissue Int (2001) 69:373–378
DOI: 10.1007/s00223-001-1006-1

"Bone specimens: At the end of experiment, the rats were anesthetized intraperitoneally with ketamine hydrochloride (50 mg/kg) and sacrificed by
exsanguination.
As in our earlier study,12 the femurs were extracted and frozen in saline-soaked tissues. Prior to mechanical testing, the bones were slowly thawed overnight at 7o C and held at room temperature on the day of testing"

COMPRESSIVE STRENGTH OF CANCELLOUS
BONE IN FLUORIDE-TREATED RATS
A Bohatyrewicz,a P Białecki, D Larysz, A Gusta
Fluoride Vol. 34 No. 4 236-241 2001 Research Report
Fluoride Vol. 34 No. 4 236-241 2001 Research Report

"Mechanical Testing
The bone was kept frozen at -20 degrees Celsius until machining. The bone tissue was not fixed and was bathed in a physiological saline solution at all stages of machining. Six cylindrical cancellous-bone specimens, 10.0 ± 0.2 millimeters (mean and standard deviation) in both length and diameter, oriented along the superoinferior axis, were manufactured from the distal part of each femur. A special jig allowed specimens to be cut from nearly identical locations, approximately two centimeters from the joint line. The specimens were produced from either the medial or the lateral side and from the anterior, central, or posterior quadrant of the metaphysis.
The specimens were thawed in normal saline solution for two hours and were tested at 19 to 21 degrees Celsius, in a hydrated state; no attempt was made to remove any bone marrow before testing."

Age-Related Changes in the Compressive Strength of Cancellous Bone. The Relative Importance of Changes in Density and Trabecular Architecture*,

RICHARD W. McCALDEN, M.D., M. PHIL., F.R.C.S.(C){dagger}, JOSEPH A. McGEOUGH, PH.D., D.SC.{ddagger} and CHARLES M. COURT-BROWN, M.B., CH.B., M.D.§, EDINBURGH, SCOTLAND The Journal of Bone and Joint Surgery 79:421-7 (1997)

I am not aware that any researcher really takes full account of *rigor mortis* and the leathering of collagen, and how those differences would affect the results of research. What this means is that most, if not all, reports and studies based on bone and cartilage strength are seriously flawed, with the strength and toughness of the structures probably overestimated.

I am no longer in clinical practice, and I have no access to research facilities. The best I can do is proposing an *in vivo* compression testing of articular cartilage that would be safe and easily performed. The ophthalmologists have a device for testing intra-ocular pressure by using

puffs of air. That device could easily be adapted to testing the compression strength of articular cartilage *in vivo*, at the time of a routine arthroscopy or open joint surgery to test if it is as soft as I have observed it is. Here is an excerpt from a Youtube video of arthroscopic knee surgery, put out by Scolex1978, showing how soft articular cartilage really is. What you see is a blunt dental probe, about 5mm angled tip, pressing into the normal cartilage over the femoral condyle.

Scolex1978
November 14, 2006
Arthroskopie nach einem Meniskusriss - Treatment after meniscus rupture

p i x e l m a p