HSS Orthopedic Research News

HOSPITAL FOR SPECIAL SURGERY

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HSS ACL Patient Registry:
Over 800 ACL Surgeries a Year

How large patient volume aids ongoing research
Load Sharing Between Menisci and Articular Cartilage Shifts after ACL Reconstruction

Injury is a well-established pre-cursor to early onset of osteoarthritis. A recent HSS study has shown a possible contribution to why that happens. The investigators identified physical changes in how the knee reacts to load bearing after ACL tear and reconstruction. The sharing of load between the meniscus and the articular cartilage is not the same after reconstruction.

Using nine cadaveric knees, the study found that after ACL reconstruction, one part of the meniscus - the medial meniscus – was carrying load similarly to an intact knee, but another part – the lateral meniscus – was not.

The lateral meniscus was taking 41% less load after ACL reconstruction than occurs in an intact knee. This means more wear-and-tear on the other parts of the knee - like cartilage and tendons - compensating for the lateral meniscus and taking on greater load. It also means probable changes in gait, which can affect weight bearing and movement all over the body.

All of those unnatural shifts in gait and weight-bearing can lead to earlier arthritis.
A Novel System to Investigate the Effect of Daily Mechanical Load on a Healing ACL Reconstruction

An HSS collaboration of surgeons, scientists, and bioengineers designed and validated a novel knee joint fixation/distraction system to study tendon-to-bone healing after ACL reconstruction in an in vivo rat model.

The system can accurately simulate a daily impact of mechanical load upon a healing ACL, allowing researchers to measure day-by-day healing response to mechanical loading, such as would be induced by joint movement. This daily tracking can help pin-point the time frame of structural changes in the bone-to-tendon healing process.

The system uses an external fixator to apply a cyclic distraction of the knee joint to anesthesized animals while monitoring the resultant force developed across the joint. The system’s accuracy was validated by using an optical kinematic tracking system to determine the local displacement of the knee.

In a pilot study using 15 rats that had ACL reconstructions using a flexor digitorum longus tendon autograft, results showed that the animals tolerated the indwelling fixator and daily anesthesia over a 10-day loading protocol.

This novel system’s ability to provide such useful and accurate day-by-day measurement of healing creates a valuable tool to study how mechanical stimuli affect in vivo bone-tendon-bone healing.
As part of the building-block process of how stem cells in the bone marrow differentiate to become the various cells that eventually develop into cartilage, tendons, bones, or whatever tissue the body needs, fibroblast cells secrete a collagen-rich matrix. Fibroblasts are also among the first responders to wounds or injury, helping the body to create the tissue it needs to make repairs.

Now, HSS doctors and scientists have found that fibroblasts of the anterior cruciate ligament (ACL) respond to cycles of load, as well as lack of strain. When cyclic strains of mechanical load were placed upon ACL fibroblasts being grown in 3 dimension collagen gels, specific cellular signaling pathways responded. Activation of the MKK3/6, SAPK pathway and its downstream target transcription factor TF-2/c-jun pathways occurred. When no load was present, these kinases and transcription factors quieted.

Knowing the involvement of specific cellular pathways helps establish a useful system for understanding how responding to mechanical load affects the body’s cellular process of building - and healing - the ACL. It can also suggest potential targets for new therapies to help speed or augment injury repair.
Because the vast majority of common arthroscopic procedures are performed with a 30° arthroscope for visualization, the utility of the 70° arthroscope has recently been forgotten. HSS surgeons explored the use of the 70° arthroscope in a wide range of procedures and identified several circumstances in which the 70° may be the wiser choice.

The 70° arthroscope provided superior visualizations in arthroscopic shoulder stabilization, distal clavicle resection, acromioclavicular joint reconstruction, rotator cuff repair, elbow arthroscopy, anterior cruciate ligament reconstruction, posterior cruciate ligament reconstruction, arthroscopy of the posterior knee compartments, hip arthroscopy, and subdeltoid shoulder arthroscopy.

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Comparing Surgical Techniques in ACL Reconstruction: An Anatomic and Biomechanical Evaluation of Transtibial Versus Anteromedial Portal Reaming

Ten human cadaveric knees (5 matched pairs) without ligament injury or pre-existing arthritis underwent ACL reconstruction by one of two techniques - either a transtibial or anteromedial portal technique. Identical 10-mm tibial tunnels were created.

Comparing the results found that the anteromedial portal reaming technique may allow for improved restoration of anatomy and stability with ACL reconstruction compared with conventional transtibial drilling techniques.

In this study, the anteromedial portal ACL reconstruction controlled tibial translation significantly more than the transtibial reconstruction with anterior drawer, Lachman, and pivot-shift examinations of knee stability. The anteromedial technique also respects the native ACL anatomy but cannot restore this anatomy with a single-bundle ACL reconstruction. Eccentric, posterolateral positioning of the guidewire in the tibial tunnel with the transtibial technique results in iatrogenic re-reaming of the tibial tunnel and significant intra-articular aperture expansion.
Double-bundle (DB) ACL reconstruction may be preferred to single-bundle (SB) reconstruction in complex cases of high-grade instability or meniscus deficiency. In this study, DB reconstruction was able to restore intact knee kinematics during the pivot shift in cadaveric specimens even in the severe injury model. SB did not.

Five fresh-frozen cadaveric hip-to-toe lower extremity specimens were used for this study (10 knees). ACL reconstructions were performed using 3 different techniques: 1) anatomical anteromedial SB, 2) nonanatomical SB (posterolateral tibia to anteromedial femur), and 3) anatomical DB.

A surgical navigation system recorded the 3-dimensional motion path of a tracked point at the center of the medial and lateral compartments during a 68-N Lachman test and a mechanized pivot-shift test. While there was no difference in the Lachman test results, DB reconstruction procedures restored intact knee kinematics during the pivot shift in all knees. SB was unable to provide the same stability in these complex injury models.
Comparing Knee Stability from Single- and Double-Bundle ACL Reconstruction Techniques

In a comparison study using 12 cadaveric knees, double-bundle reconstruction of the ACL offered greater rotational and anterior stability than either of two techniques of single-bundle reconstruction.

ACL reconstructions were performed by 3 techniques: 1) conventional single-bundle 2) anteromedial (AM) single-bundle and 3) double-bundle technique. Anterior tibial translation was measured in the intact knee, ACL-deficient knee, and the 3 ACL reconstructions in response to a Lachman test and a mechanized pivot-shift test. A surgical navigation system simultaneously tracked kinematics. Using navigation, investigators found that during the pivot shift, neither type of single-bundle ACL reconstruction stabilized the knee to the same degree as the double bundle.

While the double-bundle technique offered more stability than single-bundle techniques, there appear to be minimal differences in knee kinematics during stability testing with it and the AM graft position. Indeed, compared with the AM position alone, the double-bundle technique “overconstrained” the kinematics of the knee during a pivoting maneuver at time zero in a cadaveric model with an isolated ACL injury.
On-going Research: The high volume of ACL surgeries at HSS allows continual expansion of the hospital’s already substantial ACL Repair Patient Registry. Members of the Sports Medicine Service, including Scott Rodeo, MD, Jo Hannafin, MD, PhD, and Russell Warren, MD, work with scientists in the Hospital’s Research Division, and doctors in other HSS specialties, to analyze tissue from patients. Studies use data and samples from simple ACL tears and more serious joint damage to determine cellular and genetic differences between the two groups.

Osteoarthritis is also an important area of study. Patients who receive ACL reconstruction are being followed over time, using clinical data on who develops OA, and when, where, and how – on a cellular, radiographic, and symptomatic level – their OA progresses.

Collaborations with renown experts in inflammation from HSS Rheumatology are using biosamples collected during surgical procedures to study the role of inflammation in healing, destruction of tissue and how injury and osteoarthritis are connected.
Two Essential VEGF Receptors React Differently During Bone Healing

Discovering that VEGFR1 and VEGFR2 react differently and at different times during the healing process of bone

Bisphosphonate Treatment Modifies Bone Mineral and Matrix Properties and their Heterogeneity

After 1-year treatment, bone tissue in animal model looks more like “older bone”

Three New Risks for Fragility Fractures Identified

Study using FTIRI reveals differences in bone composition and new risks for fractures

For the First Time, Iron Overload in Mice Demonstrated to Increase Bone Loss

Osteoporosis is a frequent problem in disorders characterized by iron overload

Bisphosphonate Treatment in Subset of Women Can Impact Bone Response to Fractures

Effects of Tissue Age on Bone Tissue Material Composition and Nanomechanical Properties

New Ways of Modulating Growth in Giant Cell Tumor of the Bone

Manipulating both osteoblast and osteoclast forming activities
Bone mineral density (BMD) does not entirely explain an individual’s risk of fracture. Three new potential markers of fracture risk were recently identified using Fourier transform infrared spectroscopic imaging (FTIRI) to reveal specific differences in spatially resolved bone composition.

Iliac crest biopsies from 54 women (32 with fractures, 22 without) who had significantly different spine measurements – but not significantly different hip BMD’s – were analyzed using FTIRI. The women ranged in age from 30 to 83. Models were constructed to see if the FTIRI-measured parameters were associated with fracture. The parameters included mineral content, collagen maturity, as well as mineral crystal size and perfection. Cortical and cancellous bone were independently evaluated.

Increased fracture risks in the patients were found to be significantly associated with three new parameters: 1) Increased cortical and cancellous collagen maturity, 2) Higher cortical mineral/matrix ratio, and 3) Increased cancellous crystallinity. As expected, because of its correlation with cortical – but not cancellous – bone density, hip BMD was significantly associated with fracture risk in the cortical – but not the cancellous – model.

Now that new potential risk factors in bone composition have been identified, they can be targeted for developing possible new therapies in osteoporosis.
For the First Time, Iron Overload in Mice Demonstrated to Increase Bone Loss

Osteoporosis is a frequent problem in disorders characterized by iron overload, such as the thalassemias and hereditary hemochromatosis. The exact role of iron in the development of osteoporosis in these disorders is not established.

This study is the first to demonstrate that iron overload in mice results in increased bone resorption and oxidative stress, leading to changes in bone microarchitecture and material properties, and thus, bone loss. Continued understanding could one day lead to specific treatments and prevention therapies for osteoporosis in iron-overload conditions.

Mice were injected for two months with iron dextran. These iron-overloaded mice, when compared with the placebo group, exhibited dose-dependent increased tissue iron content and changes in bone composition.

Trabecular and cortical thinning of bone was accompanied by increased bone resorption. Iron-overloaded mice also had increased reactive oxygen species and elevated serum tumor necrosis factor-\(\alpha\) and interleukin-6 concentrations that correlated with severity of iron overload. Treatment of iron-overloaded mice with the antioxidant N-acetyl-L-cysteine prevented the development of trabecular but not cortical bone abnormalities.
Changes in Bone Microarchitecture and Biomechanical Properties in Thalassemia

Thalassemia, a genetic blood disease causing anemias, is one of the iron-overload conditions that often results in osteoporosis and fracture. Collaborators at HSS and Weill Cornell have now uncovered some of the processes of that bone loss.

The team studied the beta chain of hemoglobin in two kinds of thalassemia mice, representing two different levels of anemia experienced by people with the disease: moderate anemia (t3 mice) and lethal anemia (th3/+ mice). Lethal anemia is life-threatening and requires regular blood transfusions to sustain life. The thalassemia mice were compared to a control group of mice without the condition. Investigators found that changes in the microarchitecture and biomechanical properties of bones in mice with thalassemia are associated with decreased bone turnover and occur during the period of bone accrual.

Five specific changes were identified: 1) Trabecular bone in both kinds of thalassemia mice showed decreased bone volume fraction, number of trabeculae, and trabecular thickness; 2) cortical bone analysis showed thinner cortices and increased marrow area in th3/+ mice (P < 0.05); (3) microCT abnormalities in th3/+ mice were present by 2 months and did not worsen with age; (4) histomorphometry showed significantly decreased bone formation and resorption as well as reduced expression of cathepsin K and osteocalcin from bone (P < 0.05) in both kinds of thalassemia mice; (5) biomechanics showed reduced maximum load, maximum moment, and structural stiffness in both (P < 0.01). The thalassemia mouse model manifests bone changes reminiscent of those in humans and can be used for further bone studies in thalassemia.
Treatment for osteoporosis with bisphosphonate drugs is well known to reduce bone loss in postmenopausal women by suppressing the turnover of bone cells. But the drugs effects on other bone properties have not been characterized until now. Two frequently used bisphosphonate drugs – alendronate and risedronate – were studied to analyze the effect of a 1-year treatment, at low and high doses, on the mineral matrix and collagen of the bone.

Results found that the positive effects for decreased fracture risk derived from less bone loss are also associated with a loss of bone heterogeneity, which could be one factor contributing to increased bone tissue brittleness and micro-crack accumulation. Distal tibias from 30 normal beagles that had been treated daily for 1 year with oral doses of one of the drugs were analyzed by Fourier Transform Infrared imaging (FTIRI). Both drugs suppressed bone turnover, preventing bone loss. However, in areas where bone turnover is normally higher – cancellous and endocortical bone – this suppression was found to increase the mineral and matrix bone tissue maturity, making the areas more like “older” bone.

The significant differences observed in the mineral content and in the hydroxyapatite crystallinity distribution in bone tissue can contribute to reduced ductility and micro-crack accumulation. No significant differences were observed between low and high dose, nor between treatment with either drug.
As bone makes new bone cells to repair itself, evidence suggests that a growth factor known as VEGF (vascular endothelial growth factor) contributes to the process. This study discovered that two essential VEGF receptors – VEGFR1 (VEGFR1/Flt-1) and VEGFR2 (VEGFR2/Flk-1/KDR) – react differently and at different times during the healing process of bone.

Analyzing mRNA and protein levels in mouse rib fractures through four healing phases, uncovered expression signatures of the VEGF-VEGFR axis in endochondral bone repair. The four healing phases were post fracture day (PFD) one, three, seven and fourteen. Baseline response was measured on PFD 1. Inflammatory response was measured on PFD 3. Initiation of callus development calculated on PFD 7. And the presence of a mature callus observed on PFD 14.

While expression of VEGFR1 was monophasic during healing, VEGFR2 showed a biphasic profile with significantly increased expression during callus formation and maturation. Expression of VEGF showed a more gradual increase during callus formation. The protein level for VEGFR1 was below detection sensitivity during the initial healing phase. It then restored to a stable level detectable during all subsequent healing phases. Thus, the VEGFR1 protein levels mirrored the transcript expression profile.

In comparison, the protein level of VEGFR2 increased gradually during the healing phases and peaked during the maturation of the callus on PFD 14. It correlated well with the transcriptional expression of VEGFR2. Intact bone from age-matched male mice expressed considerable protein levels of VEGFRI and VEGF, but no detectable VEGFR2
Identification of a rare atypical ST fracture pattern specifically associated with long-term bisphosphonate treatment suggests that bisphosphonate use may alter bone quality and fracture resistance in a subset of patients.

Cortico-cancellous biopsies were removed from the lateral aspect of the proximal femur, adjacent to the fracture site, of postmenopausal women admitted for repair of intertrochanteric (IT) and ST fractures. Distributions of tissue mineral properties were narrower in the +BIS group. Because reductions in the bone’s compositional heterogeneity may reduce tissue-level resistance to crack propagation, our data preliminarily suggest that over-suppression of bone turnover may alter bone quality and contribute to the increased risk of subsequent fractures in a subset of patients.

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The understanding and predicting of age-related fractures has been missing a crucial component: how the material property of bone changes with age. Now, a study brings new knowledge of aging bone.

Cortical bone osteons - the functional unit of cellular bone structure - contain a natural gradient that indicates tissue age, providing an ideal location for measurement and study of bone over time. Using osteons from 12 female baboons representing the baboon lifespan (aged 0–32 years) this study examined effects of tissue and animal age on mechanical properties and composition of bone.

As young animals age, mineral-to-matrix ratio and carbonate substitution increased 12% and 6.7%, respectively, per year, corresponding with a nearly 7% increase in stiffness and hardness. Carbonate substitution and aligned collagen peak height ratio both increased with tissue age, increasing 6–12% across the osteon radii. Indentation modulus most strongly correlated with mineral-to-matrix ratio, which explained 78% of the variation in indentation modulus. Overall, the measured compositional and mechanical parameters were the lowest in tissue of the youngest animals.

These results demonstrate that composition and mechanical function are closely related and influenced by tissue and animal age.
Knowing how aging affects the cellular and mineral structure of bone can help lead to more effective treatments for fractures, osteoporosis, and bone diseases. This study of 12 cadaveric bones, using Fourier transform infrared spectroscopy imaging, revealed age to have a significant effect on several aspects of bone.

Older bone exhibited a higher collagen crosslink ratio than middle-aged. Interstitial tissues exhibited higher mineral content compared to both secondary and old osteonal tissues. Older tissue showed decreased toughness of interstitial tissue observed in micro-compression tests. A trend toward age-related increases in mineral crystallinity was also observed in this study. Considered with the age-related increases in the collagen crosslink ratio, this is indicative of the need for collagen stabilization through crosslink maturation in order for mineral formation and growth to proceed.

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Osteoporosis not only lowers bone mass, it also alters bone tissue composition, though effects of these compositional changes have not been examined. A new study shows significant variations in tissue mechanical properties with tissue age.

Using tissue from the femoral cortices of growing rats, the nanomechanical properties and composition of regions of differing tissue age were characterized using nanoindentation and Raman spectroscopy. In addition, spatial maps of the properties of periosteal tissue were examined to investigate in detail the spatial gradients in the properties of newly formed tissue.

Newly formed tissue (0–4 days) was 84% less stiff and had 79% lower mineral:matrix ratio than older intracortical (15–70 days) tissue. Tissue modulus, hardness, mineral:matrix ratio, and carbonate:phosphate ratio increased sharply with distance from the periosteum and attained the properties of intracortical tissue within 4 days of formation. The mineral: matrix ratio explained 54% and 62% of the variation in tissue indentation modulus and hardness, respectively.
Potential new treatment targets for giant cell tumor (GCT) of the bone and new ways of gaining insight into GCT molecular behavior were uncovered in a recent collaboration.

GCT is an osteolytic tumor comprised, for the most part, of three different kinds of cells. This study targeted one of those three: fibroblast-like stromal cells, also known as giant cell tumor stromal cells or GCTSC. Investigators had observed genetic markers indicating GCTSC might be open to reprogramming early in the bone-making process in a way that would halt a tumor’s abnormal growth.

At osteogenesis, when stem cells in the bone marrow differentiate into early new bone cells called osteoblasts, other normal bone cells, called osteoclasts, are being reabsorbed into the bone. Old cells being reabsorbed and new cells emerging are part of the balance of normal bone growth. Investigators thought the GCTSC might be reprogrammed during osteogenesis to break down a vicious cycle between the GCTSC and osteoclast-like cells, and by doing so, repress the osteoclastic (bone eating) activity.

There are two cellular pathways involved in the transition of stem cells into osteoblasts during osteogenesis that the investigators felt were likely for manipulation: Wnt and BMP pathways. (BMP stands of Bone Morphogenic Protein, which is a growth factor that encourages new bone.) The investigators also thought they would see impact on two proteins that are part of the regulation of the cellular processes of bone making. Those proteins are receptor activator of (continued, click here)
nuclear factor kappa-B ligand (RANKL) and osteoprotegerin (OPG) GCTSC were isolated from seven tumor samples. The samples were cultured with growth factors that could impact the Wnt and BMP pathways and encourage osteoblast formation. After 12 days, changes in the tumor cells were observed. Activation of the Wnt and BMP pathways had produced results, some surprising.

The growth factors BMP-2 and SB415286 had caused the GCTSC to demonstrate a two-fold increase in markers indicating osteoblast activity. Activating the Wnt pathway, or using osteogenic medium, also affected indications of osteoblast-forming as a marked increase in the OPG/RANKL ratio occurred. A surprising impact on osteoclasts had also occurred. BMP was observed to increase osteoclast-inducing activity. This effect may be attributed to the differential effects of the Wnt and BMP pathways on OPG/RANKL production.

Being able to manipulate both osteoblast and osteoclast forming activities in giant bone cell tumors gives new targets for treatments. It also brings investigators new ways to uncover more aspects of the cellular activities of GCT.

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Multiple-Angle Target for New Therapies in Osteoarthritis: NF-kappaB Signaling

Use of a Biphasic Scaffold for the Treatment of Isolated Osteochondral Defects of the Knee

Validation of Cartilage Thickness Using MRI, Indentation Analysis, and a Novel Phantom

A novel ability to accurately measure cartilage tissue thickness by magnetic resonance imaging (MRI)

IGF-I Increases the Interface Strength Between a Novel Scaffold and Articular Cartilage

Successful test using a unique, non-biodegradable, polyvinyl alcohol (PVA) system

Mechanical Load Inhibits IL-1 Induced Matrix Degradation in Articular Cartilage

New understanding about the interaction of the “wear-and-tear” and inflammatory processes of OA.

The Epigenetic Effect of Glucosamine and a Nuclear Factor-Kappa B Inhibitor on Primary Human Chondrocytes - Implications for OA

Epigenetic effects happen “above the DNA”. New study reveals epigenetic effects in cartilage cellular processes.

Defining the Molecular Parameters of How Osteoarthritis Impacts Cartilage

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HSS Cartilage Research

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Osteoarthritis can degrade cartilage in the joints by both wear-and-tear and inflammation. Understanding the cellular mechanisms involved with each kind of damage - and how they may be both separate and dependent processes - can help unlock ideas for treatments and prevention. A recent, surprising discovery by HSS investigators brings new understanding about the interaction of the two processes.

One of the prime cellular activators of the body’s inflammatory process is the cytokine IL-1. It is a main messenger in the molecular signaling that tells the body to start and maintain inflammation. This recent study examined cartilage’s cellular response when being simultaneously subjected to both mechanical load - thus simulating wear-and-tear - and IL-1 – thus triggering inflammation. Researchers theorized the combination would result in accelerated degrading of cartilage, specifically in its extracellular matrix (ECM).

Surprisingly, a specific combination of load and IL-1 resulted in less damage to the articular cartilage, not more. The mechanical load at a level of 0.5 MPa actually inhibited the inflammatory process of the IL-1. In fact, the degradation of the cartilage matrix associated with aggrecan cleavage by aggrecanases and MMPs was inhibited by adding the 0.5 MPa load during IL-1 triggered inflammation for three days. However once the load was removed after the three days the damage to the cartilage from the inflammation increased.

A lower level of load - the 0.2 MPa stress - did not stop or slow the damage to the articular cartilage triggered by the inflammation from the IL-1 in any timing or test scenario. The molecular mechanisms involved in this process are not clear but probably involve altered mechanochemical signal transduction between the ECM and chondrocyte.

The implications of these results could be that, one day, on a molecular level, science can understand how movement - like specific activities, sports, daily life, repeated motions, physical therapy, or weight-bearing exercise - can both aggrevate and prevent inflammation and use that knowledge to help arrest or even prevent the cartilage destruction of osteoarthritis.

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A novel ability to accurately measure cartilage tissue thickness by magnetic resonance imaging (MRI) has been validated by a collaboration of HSS radiologists and bioengineers.

Using seven cadaveric bovine knees, the team matched point-to-point measurements of cartilage by two methods. First, they calculated cartilage thickness by using MRI and then, immediately, physically measuring the actual cartilage on the knee, using indentation analysis.

To further calibrate the calculations, a novel phantom filled with dilute gadolinium solution was rigidly attached to each knee specimen. Since the exact properties and measurements of this phantom were known – and would be consistent from knee-to-knee – it could be used to calibrate the image-based and laboratory-based data sets.

A total of 105 paired MRI-indentation thickness data points were analyzed. A significant correlation between the paired data was found ($r=0.88, p<0.0001$), validating a useful tool for clinical evaluation of in-vivo cartilage thickness by MR.
IGF-I Increases the Interface Strength Between a Non-degradable PVA Scaffold and Articular Cartilage

A challenge to developing an implantable, synthetic scaffold that will help to repair focal articular cartilage lesions is that cartilage has poor capacity for integrating the scaffold with the native tissue. One potential solution is supplementing the connection site with growth factors. It is hoped that growth factors will encourage new cartilage cells to migrate across the scaffolding either by stimulating cartilage matrix synthesis or stimulating the rate of growth of new chondrocyte cells. The more cells that enter and cross the scaffold, the stronger the integration of implant and intact cartilage becomes, and the more likely a good repair can occur.

Two such potential supplements - Insulin-like growth factor (IGF-I) and fibroblast growth factor-2 (FGF-2) – were recently tested on a novel HSS-developed scaffolding system. IGF-I increased the scaffold-cartilage interface strength up to 17-fold. FGF-2 created no impact.

The scaffold was a unique, non-biodegradable, polyvinyl alcohol (PVA) system with a macroporous morphology that allows for chondrocyte ingress from surrounding cartilage and matrix synthesis after ~20 days of in vitro culture.

The scaffold was fabricated and placed in cartilage taken from the trochlear groove and femoral condyles of calves. Then, after a delay to allow for the initiation of chondrocyte ingress – based on the previous knowledge – the growth factor IGF-I was administered. Results showed that the IGF-I supplementation increased the scaffold-cartilage interface strength up to a 17-fold, a significant increase. However, the expected interaction with FGF-2 – hoping to increase chondrocyte migration across the scaffold – did not occur.

While the IL-1 supplementation was successful, it was not for all the expected reasons. Time could be an important factor. In this study the addition of growth factors was delayed based on previous in vitro data. Now, further studies are planned to determine the optimal time line for when to deliver IL-1 to further enhance this successful augmentation of the integration of scaffold and cartilage.
Use of a Biphasic Scaffold for the Treatment of Isolated Osteochondral Defects of the Knee

Treatment of isolated femoral cartilage lesions with a biphasic implant results in an improvement in clinical outcome measures at a minimum two-year follow up. Thirty patients (31 knees) underwent biphasic scaffold implantation. Evaluating their results at a follow-up interval of 32.8 months later (range: 24-48) found improvements in several subjective tests.

The mean Active Daily Living score increased from 62.7 to 82.4 ($p<0.001$). The mean International Knee Documentation Committee score increased from 45.1 to 71.3 ($p<0.001$). There was no significant change in the Marx Activity score. At latest MRI evaluation 90% of plugs demonstrated iso- or hyperintense cartilage signal, and 69% of plugs demonstrated near complete to complete fill. Moderate to good bony incorporation was noted in 64% of plugs, with 49% demonstrating a flush morphology. Subchondral edema was minimal to absent in 72% of plugs, while plug hypertrophy, displacement and bony overgrowth were rare.

While the majority of plugs demonstrated a favorable MRI appearance, clinical outcome did not correlate with implant morphology.

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One of the most basic molecular processes in the body’s creation of necessary new cells – including the replacement of old cells, the creation of new immune system cells to fight invaders, or the repair of the body’s tissues and organs – is how the precise bits of genetic information needed for that one new cell are transcribed from the entire genetic map of the body’s DNA.

Every cell in the body has the entire DNA code, but only the information outlining the one new cell’s genetic structure is required to create or replicate it. And this smaller set of single cell information has to be precisely copied – or transcribed – to RNA in order for the body to use it. A complex of proteins called “transcription factors” controls the process by binding to specific DNA regions so only the exact, necessary information is transcribed. Different transcription factors are triggered into action by different situations. One essential transcription factor being studied in cartilage cells is “nuclear factor kappa-light-chain-enhancer of activated B cells” – or NF-kappaB. Recently, collaborators have explored how NF-kappaB is importantly involved in the transcription processes regulating cartilage cells in osteoarthritis.

In osteoarthritis, NF-kappa-B involvement can be triggered by a host of stress-related stimuli including cellular messages to create inflammation, degrade the extra-cellular cartilage matrix, and react to excessive mechanical stress. Activated NF-kappaB regulates the expression of components of these cellular messages including cytokines and chemokines, adhesion molecules, inflammatory mediators, and several matrix degrading enzymes. (continued, click here)
One reason researchers think that NF-kappa-B might be a target for new osteoarthritis therapies is that NF-kappa-B has direct impact on the messages instructing cartilage tissue remodeling and the creation and behavior of chondrocytes – the cellular building blocks of new cartilage. Osteoarthritis affects chondrocytes by pushing them to differentiate inappropriately. Thus, the chondrocytes are not able to fabricate new cartilage that is the same as that laid down during development and growth. Since NF-kappa-B appears to be involved in controlling differentiation in cartilage, perhaps therapies could target NF-kappa-B, aiming to stop the differentiation process from going awry in osteoarthritis.

This work is only beginning, but one day, specific drug modalities – siRNAs or other biological inhibitors that are targeted to the activating NF-kappaB kinases IKKalpha or IKKbeta or specific activating canonical NF-kappaB subunits – might be used to develop new therapies that target specific NF-kappa-B pathway components to prevent and heal osteoarthritis.

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Osteoarthritis (OA) is triggered by a range of not fully understood factors – genetic, inflammatory, environmental, and mechanical. The search for disease-modifying therapies considers all these potential risk factors as targets.

Glucosamine (GlcN) is a widely used OA therapy. Whether by off-the-shelf supplementation or clinical prescription, GlcN’s efficacy and mechanism of action remain controversial. Recently, investigators considered whether GlcN has the potential to modulate important molecular mechanisms of OA in an epigenetic process. The answer is yes.

Epigenetics is a vital and growing area of study in OA. An epigenetic molecular process somehow occurs within cells without instructions from the DNA. Cells change, but the DNA doesn’t. “Epi” means “over” or “above” in Greek. Thus, the “epigenetic effect” is “over DNA”. The cells can continue their epigenetic changes for an unknown amount of time - for a generation, a year, many years – but the underlying DNA from which the original cells took their genetic information remains unchanged.

Epigenetics affects the behavior of cells in OA cartilage in ways not encoded in ways that are not encoded in the DNA. This study investigated whether GlcN affects one of these epigenetic OA cellular processes, namely DNA methylation. Femoral cartilage cells obtained during fracture repair surgery from volunteer patients were cultured in different mixtures of GlcN and various growth and/or inflammatory factors that could effect gene transcription and, thus, cellular actions. (continued, click here)
Five weeks later, significant effects were found in cultures involving a transcription factor called nuclear factor-kappa B (NF-kB) and its pro-inflammatory effects in chondrocytes. Specifically, the expression of the gene encoding IL-1beta, a cytokine that triggers inflammation, was inhibited by GlcN and a NF-kB inhibitor (known commercially as BAY), prevented cytokine-induced demethylation of a specific CpG site of the IL1B gene promoter.

“Demethylation” means the removal of methyl groups from the DNA. When a molecular messenger, or perhaps an enzyme, removes methyl groups, then a cellular process is triggered or prevented from occurring. In this case, the mix of GLcN and BAY somehow demethylated the CpG site, which triggered expression of the normally silent IL1B gene, thereby halting inflammation. In humans, less inflammation can mean less cartilage damage and less pain.

Finding that GLcN acts epigenetically and that NF-kB has a role in human chondrocyte DNA demethylation in ways that signal inflammation to cease opens new possibilities for developing disease-modifying agents for treating OA.

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Defining the Molecular Parameters of How Osteoarthritis Impacts Cartilage

On-going Research: At what point, on a cellular level, does a repaired ACL develop the first molecular indicators of osteoarthritis? Does the inflammation that aids the body’s healing process differ – on the smallest molecular level – from the inflammation that destroys cartilage? What are the normal molecular responses in the daily life of healthy cartilage and how do they change during arthritis? What molecular processes of cartilage degradation and repair are the same and what are different?

Answers to these and other essential questions about how cartilage degrades and can be repaired are the goal of the HSS Laboratory of Cartilage Biology, directed by Senior Scientist Mary B. Goldring, Ph,D in the Tissue Engineering, Repair and Regeneration. Interdisciplinary explorations led by Dr. Goldring are revealing how changes in gene and protein expression occur – and differ– in cartilage during every phase of osteoarthritis. Collaborators include HSS scientists, bioengineers, and clinician-scientists from a range of specialties, including surgery, radiology, and the renown inflammation experts of HSS Rheumatology. NIH and ARRA grants support these important investigations.

HSS performs more hip surgeries and total knee replacements than any other hospital in the nation. HSS surgeons also perform over 800 ACL injury repairs a year. The large patient volume, and resulting substantial Patient Registries, mean biopsies and patient data are available at every point of the osteoarthritic process.

Each significant molecular mechanism discovered by Dr. Goldring’s lab has the potential to become part of new treatment strategies for every stage of osteoarthritis. For example, uncovering molecular changes that occur in repaired cartilage even before the first twinge of symptom is experienced can help prevent the common early onset of arthritis that follows sports injuries. Knowing how cartilage reacts molecularly can help guide cartilage implant and scaffolding design, as well development of potential growth factors to augment cartilage cell integration and surgical healing. Unlocking the molecular secrets of cartilage can, ultimately, help prevent and relieve some of the most painful conditions of the nation’s most debilitating disease – osteoarthritis.
Novel Docking Technique for Elbow Medial Ulnar Collateral Ligament Reconstruction

Review of the 3-strand graft technique in 21 overhand athletes shows excellent results.

Older Baseball Players Experience More Combined Flexor-Pronator Mass and Ulnar Collateral Ligament Injuries in Elbow

Review of 187 male baseball players who had received an ulnar collateral ligament reconstruction shows age is a factor in injury and recovery.

Measurements Show How Neglecting Elbow Conditions Can Lead to Worse Injury

Study using cadaveric elbows shows importance of prompt clinical recognition of ulnar collateral ligament insufficiency before further damage is done.
When athletes who use overhand throwing in their sport experience symptoms in their elbow due to ruptured or insufficient ligament and have a desire to resume competitive play, the standard of care is to perform an elbow ulnar collateral ligament (UCL) reconstruction.

Like all surgical techniques, the UCL has evolved, and at HSS a novel “docking” modification of Jobe’s original UCL technique was developed by David W. Altchek, MD, Co-Chief of the Sports Medicine and Shoulder Service. Slight modifications have evolved Dr. Altchek’s docking technique as well. Arthroscopy is no longer routinely performed, and in some cases, a 3-strand graft is used.

This study reviews the 3-strand graft technique in 21 overhand athletes with clinical and radiographic evidence of UCL insufficiency. There were 5 professional, 11 college, and 5 high school male baseball players in the reconstructed group. Athletes were evaluated postoperatively by use of the Conway Scale. 90% of the patients - 19 out of 21 - had excellent results. The other 2 patients experienced good results. There were no complications. The modified docking technique using a 3-strand graft proves to be produce excellent results in UCL surgery for high-performance, throwing athletes.
187 male baseball players between 14 and 42 had an ulnar collateral ligament reconstruction over a six year period by one surgeon. There was a statistically significant difference in age showing that younger players (20.1 years) were in a group that experienced ulnar collateral ligament injuries alone, while the older players (33.4 years) were in a group that experienced combined Flexor-Pronator and ulnar collateral ligament injuries.

Ulnar collateral ligament reconstruction techniques have afforded baseball players up to a reported 90% return to prior or higher level of play. But combined flexor-pronator and ulnar collateral ligament injuries in baseball players may portend a worse prognosis. Only 12.5% return to prior level of play. Older age (≥30 years) is a risk factor in the development of this combined injury.

When combined flexor-pronator/ulnar collateral ligament injury is suspected preoperatively, patients should be counseled on expected outcomes appropriately.

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Measurements Show How Neglecting Elbow Conditions Can Lead to Worse Injury

Throwing athletes who continue to play despite valgus laxity from ulnar collateral ligament insufficiency are risking further injury. This study documents how the considerable force generated by throwing - and subsequent chondromalacia within the posteromedial aspect of the elbow - create a plausible mechanism for advancing injury.

Six fresh human cadaveric elbows were dissected and subjected to a static valgus load, to simulate an elbow condition in a throwing athlete. The elbows were then put through the movement, pressure and load experienced in early acceleration phase of the throwing motion with the elbow in 90° of flexion. Pressure-sensitive Fuji film measured the contact pressure, contact area, and shift in contact area across the posteromedial elbow before and after sectioning the anterior bundle of the ulnar collateral ligament.

All of the measurements showed risk. The contact pressure between the tip of the olecranon process and the medial crista of the posterior humeral trochlea significantly increased, from an average of 0.27 ± 0.06 kg/cm² to 0.40 ± 0.08 kg/cm². The contact area also significantly decreased, from an average of 30.34 ± 9.17 mm² to 24.59 ± 6.44 mm², and shifted medially on the medial humeral crista, which corresponds to the position of the posteromedial chondral lesions that was observed in throwing athletes in the authors’ clinical practice.

The findings illustrate the importance of prompt clinical recognition of ulnar collateral ligament insufficiency before further damage is done.
Sutures Coated with PDGF Improve Tendon Healing in a Rat Model

Study shows growth factor coated sutures can improve and/or accelerate healing time in Achilles tendon repairs in rats.

Reconstruction of the Spring Ligament Using a Peroneus Longus Autograft Tendon Transfer

First study on technique shows few complications

Intermediate Follow-up Shows Deltoid Ligament Reconstruction Effective in Treating Flatfoot Deformity

Tests showed how tears by injury or cutting by surgery affect the meniscus differently.

Lateral Ligament Repair and Reconstruction Did Not Restore Contact Mechanics of the Ankle Joint or Motion Patterns of the Hindfoot

Comparing results of several lateral ligament surgical repair and reconstruction techniques

A Rotational Scarf Osteotomy Decreases Complications When Treating Hallux Valgus

A retrospective review of 140 patients
Coating sutures used in surgery with a plate derived growth factor (PDGF) improved the function of repaired Achilles tendon in rats.

In this study, 4-0 VICRYL sutures were dip-coated with four different substances: 1) sodium acetate buffer (carrier control), (2) 0.3 mg/ml rhPDGF-BB, (3) 1.0 mg/ml rhPDGF-BB, and (4) 10.0 mg/ml rhPDGF-BB. Repairs were made to the Achilles tendons of randomly-assigned Sprague-Dawley rats.

The PDGF coating was able to improve the material properties (ultimate tensile stress, Young’s modulus) of repaired tendons in a positive dose-dependent fashion, with the most pronounced difference in the highest dose group.

Though there were no significant histological differences between the coatings, the biomechanical data provides promise that growth factor coated sutures can improve and/or accelerate healing time in Achilles tendon repairs.
Reconstruction of the Spring Ligament Using a Peroneus Longus Autograft Tendon Transfer

The spring ligament complex provides one of the main static supports of the medial arch of the foot. When bony procedures do not fully correct an injury or deformity, reconstruction surgery is considered. A surgical technique developed at HSS reconstructs a spring ligament using a peroneous longus tendon allograft left at its distal attachment and passed through the navicular followed by either a calcaneal or tibial drill hole. This is the first research to report on the technique.

Thirteen consecutive patients (14 feet) undergoing flatfoot surgery with spring ligament reconstruction for cases in which lateral column lengthening failed to correct talonavicular deformity were reviewed at a mean 8.9 (+/- 1.9) years after surgery. Standard test scores were assessed, as were standard weightbearing radiographs. Hindfoot alignment and eversion strength were measured.

The AOFAS ankle-hindfoot score increased from 43.1 to 90.3 (p = 0.001). The postoperative FAOS pain subscale and overall SF-36 were 83.7 (range, 67.9 to 100), and 77.3 (range 37.8 to 95.6) respectively. The AP first tarsometatarsal angle (p = 0.015), talonavicular coverage angle (p = 0.003), lateral calcaneal pitch (p = 0.002), and lateral talonavicular angle (p = 0.017) improved significantly and were within normal ranges postoperatively. The mean hindfoot alignment measured 2.7 degrees of valgus. All but one patient had normal (5/5) eversion strength.

This first study demonstrates that reconstruction of the spring ligament resulted in few complications and might be considered as an alternative to arthrodesis in patients with ruptures of the spring ligament and deformity that does not correct fully with bony procedures alone.
From 7 to 10 years after their surgery, patients with deltoid ligament reconstruction using a peroneus longus tendon transfer were demonstrating how this is a useful technique for reducing tibiotalar tilt in the setting of stage IV flatfoot deformity.

Weightbearing radiographs of the ankle showed that the valgus talar tilt had improved from 7.7 degrees preoperatively to 2.1 degrees postoperatively. Mean ankle range of motion was 47 degrees (range, 40 degrees to 55 degrees). Mean hindfoot alignment was 4 degrees valgus (range, 1 degree varus to 8 degrees valgus).

Tests showed correction and function were maintained at intermediate-term follow-up demonstrating the value of this technique in treating flatfoot deformity.

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Lateral Ligament Repair and Reconstruction Did Not Restore Contact Mechanics of the Ankle Joint or Motion Patterns of the Hindfoot

When ankle sprains have damaged both the lateral ligaments of the hindfoot and the osteochondral tissue of the ankle joint, and non-surgical treatments have failed, operative approaches may be indicated to restore normal motion and ankle function.

This study of eight cadaveric specimens, compared the results of several lateral ligament surgical repair and reconstruction techniques to an intact, normally functioning foot and ankle. Some techniques did provide improvements. But all surgical repairs left the foot and ankle without full return to function.

Repair techniques used on the specimen ankles included sectioned anterior talofibular and calcaneofibular ligaments, the Broström and Broström-Gould repairs, and graft reconstruction. Robotic technology applied identical pressure and loads to the repaired ankles. The contact mechanics of ankle function were simultaneously measured. None of the surgical techniques returned the repaired foot and ankle to full function, motion, and equal contact mechanics as the intact specimen.

As impaired function and altered contact mechanics can leave an individual open to development of osteoarthritis, long-term studies are needed to see which repairs, despite their improvements, leave the patient more prone to osteoarthritis than others.
The traditional scarf osteotomy for bunions has been associated with a wide range of complication rates - between 1.1% and 45%. Aiming to reduce the complications, HSS surgeons modified this traditional technique with a rotational osteotomy. This modified technique has a low complication rate (9%) and reduces the risk of troughing. This procedure can also reduce a high degree of IM angle deformity while restoring function to the forefoot.

A retrospective review of 140 patients (38 men and 102 women) with a mean age of 54 years (range, 35–66 years) who underwent rotational surgery with the HSS-modified technique, showed continued good results for 24 months after surgery (mean, 41 months; range, 24–68 months). Only 11 patients (9%) experienced any complications.

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First Study to Evaluate Functional Performance After Wrist Fusion

Evaluating repaired wrists conducting normal tasks, giving clinicians more functional parameters of healing.

Improved Outcomes for Patients with Soft Tissue Sarcoma of the Hand

Achieving negative surgical margins can improve outcomes.

New Technique: Extensor Tendon Centralization at the Metacarpophalangeal Joint

Brings relief to persistent painful snapping of the extensor tendon.

The Mechanical Axes of the Wrist Are Oriented Obliquely to the Anatomical Axes

How the wrist performs, mechanically, in twenty-four different directions.

Growth Differentiation Factor 5 Has Early Beneficial Effect on Zone II Flexor Tendon Repair in a Rabbit Model

Coating sutures with GDF5 improved healing of tendon repairs in this study of 44 New Zealand White rabbits.
When midcarpal wrist pain cannot be managed by conservative measures, surgical fusion with bone grafts can be an option for relief. Until now, measurements of successful outcomes in such midcarpal arthrodeses have only described the wrist in isolated planes of motion. This study, for the first time, evaluates repaired wrists conducting normal tasks, giving clinicians more functional parameters of healing after wrist fusion.

Ten healthy males and ten males who had undergone midcarpal arthrodesis on their dominant wrist performed 15 trials of dart, football, and baseball throwing, basketball shooting, pouring from a cup, and hammering nails.

Performance was significantly worse in patients who had received the midcarpal arthrodesis surgery for dart throwing, basketball shooting and hammering. No differences in performance were found in baseball and football throwing or pouring. Wrist coupling was significantly reduced for dart throwing and basketball shooting in the surgical group. Angular excursion at the wrist for the surgical group was decreased for all the tasks except pouring. Offset in the RUD direction was significantly different for basketball shooting, football throwing and hammering in arthrodesis patients. FE offset was found to be different for dart throwing and hammering.

As results showed decreased wrist coupling can reduce functional performance in tasks requiring accuracy and force, surgical and rehabilitative efforts should be focused on the restoration of wrist coupling following injury.
When injury to the extensor hood of the metacarpophalangeal joint has failed conservative treatment, this can result in persistent painful snapping of the extensor tendon. Surgery may then be considered.

In the past, surgical techniques for these injuries have involved both tightening and repositioning of adjacent structures to try to restore extensor tendon alignment. HSS hand surgeons have developed a new technique that has brought relief to patients. This new technique uses a free tissue graft that is passed through bone and sutured upon itself to effectively create a tunnel for the tendon to run in and prevent snapping.

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A long-standing collaboration between the HSS Hand Service and Memorial Sloan Kettering focuses on treatment of soft tissue sarcoma (STS) tumors in cancer of the hand. In earlier studies, repeat resection or amputation was found to improve outcomes. Since then, collaborators have aggressively pursued the strategy of achieving negative resection margins, using standard or modified amputations when needed, and performing repeat resections to negative surgical margins when they were not achieved at the time of initial surgery.

A recent review of 53 patients who were treated for STS tumors between 1996 and 2005, determined that this aggressive surgical approach can result in better clinical outcomes.

Of the 53 patients reviewed, 6 had positive margins at the time of initial surgery. 3 of those patients underwent repeat resection to negative surgical margins, 3 did not. All 3 who did not, developed local disease recurrence; 2 of them also developed distant metastases.

Of the 50 patients with negative resection margins - either at initial surgery or by subsequent resection – only 2 developed distant metastases. A total of 5 of the negative margin patients developed local and/or distant disease recurrence, and they all had deep tumors. The median Musculoskeletal Tumor Society (MSTS) score of the negative margin patients was 29 (interquartile range, 27-30). Patients who underwent more extensive resections, such as double ray amputations, had lower MSTS scores.

These findings underscore that care must be taken when planning biopsies of hand tumors and that achieving negative surgical margins can improve outcomes.
Few studies have thoroughly examined the mechanical properties of the healthy wrist. Even complex motions of the wrist, involving several articulations, have usually been described in only four anatomical directions. Now, a new study in a long-standing collaboration between HSS and Brown University has determined how the wrist performs, mechanically, in twenty-four different directions.

Using a custom-designed jig and six fresh-frozen cadaver wrists, the team moved the wrists through the four commonly observed directions of flexion, extension, ulnar deviation, and radial deviation. In addition, twenty other directions that were a combination of these anatomical directions were also observed and measured.

Results showed that the wrist’s range of motion is ellipsoidal in shape. The mechanical axes of the wrist are oriented obliquely – not collinear – to the anatomical axes. The wrist’s primary mechanical direction is that of the dart thrower’s motion – the radial extension and ulnar flexion.

The largest wrist range of motion was a mean of $111.5^\circ \pm 10.2^\circ$, in the direction of ulnar flexion, $30^\circ$ from pure flexion. The largest stiffness (mean, $0.4 \text{ Nm/deg}$) was in the direction of radial flexion, while the smallest stiffness (mean, $0.15 \text{ Nm/deg}$) was in the direction of ulnar flexion.

Understanding the mechanical function of the wrist can aid clinical treatment decisions, including development of new joint replacement surgical techniques and implant designs.
Coating sutures with growth differentiation factor 5 (GDF5) improved healing of tendon repairs in this study of 44 New Zealand White rabbits. Two lacerations were created in the zone II flexor tendon of each rabbit forepaw and were immediately repaired. One repair was made with GDF5 coated sutures, the other with uncoated sutures. Rabbits were euthanized at 21 and 42 days after repairs. Analysis showed the GDF5 coating of sutures had early beneficial effect on healing.

Tendons repaired without coated sutures demonstrated distinct borders at the transection site and less endogenous repair at 3 weeks. The repairs made with coated sutures showed a better SosloWSky histological score for collagen at both time factors, and a greater capacity for load at 3 weeks. Though by six weeks, no difference in load handling was demonstrated. And all tendons failed at the repair site.

Results suggest that modulation of zone II flexor tendon repair healing using growth factors may reduce the incidence of complications, such as rupture and fibrosis.
A mobile compression device was shown to prevent thrombosis as well as low-molecular-weight heparin when used in total hip arthroplasty in this eight-hospital trial.

Comparing MRI signal changes indicating osteolysis to retrieved tissue from osteolysis-caused revision surgery.

In some patients, there are pulmonary reactions during bilateral THA that do not occur during the first hip replacement in the same surgery.

Review of 56 patients with Cerebral Palsy who had THA. Follow-up was 9.7 years (range, 2–28 years).

From the HSS Patient Registries, 436 alumina-on-alumina ceramic, cementless, primary THA’s were examined.
Eight hospitals, including HSS, Cleveland Clinic, and Mayo Clinic, joined together for an important, prospective, randomized trial comparing the thrombosis prevention capability of a mobile compression device to that of low-molecular-weight heparin, the blood-thinning drug when used in total hip arthroplasty (THA).

The study of 410 patients (414 hips) showed that the compression device works as well as the drug. Heparin, like all blood thinners, is associated with serious side effects. The compression device is not. HSS intends to use the device in its THA protocol instead of the drug for all patients who are discharged within 48 hours after surgery.

The comparative results of the study showed the rate of major bleeding events was 0% in the compression group and 6% in the low-molecular-weight heparin group. The rates of distal and proximal deep venous thrombosis were 3% and 2%, respectively, in the compression group compared with 3% and 1% in the heparin group. The rates of pulmonary embolism were 1% in the compression group and 1% in the heparin group, and there were no fatal pulmonary emboli. Within the twelve-week follow-up period, two events (one deep venous thrombosis and one pulmonary embolus) occurred in one patient in the compression group following negative findings on duplex ultrasonography on the twelfth postoperative day. There was no difference between the groups with regard to the prevalence of venous thromboembolism.
A collaboration of HSS surgeons and anesthesiologists has found that in some patients there are pulmonary reactions during bilateral THA that do not occur during the first hip replacement in the same surgery. These new findings suggest that bilateral procedures should be cautiously considered in patients with diseases suggesting decreased right ventricular reserve.

24 patients without previous pulmonary history undergoing cemented bilateral THA under controlled epidural hypotension were enrolled in the study. Pulmonary artery catheters were inserted and hemodynamic variables were recorded at baseline, 5 minutes after implantation of each hip joint, 1 hour, and 1 day after surgery. Mixed venous blood gases and complete blood counts were analyzed at every time point.

An increase in pulmonary vascular resistance was observed after the second – but not the first – hip implantation when compared with values at incision. Pulmonary vascular resistance remained elevated 1 hour after surgery. Pulmonary artery pressures were significantly elevated on postoperative day 1 compared with those at baseline. The white blood cell count increased in response to the second hip implantation but not the first compared with incision.

While the transient and rarely clinically relevant effect of bone and cement embolization is a known phenomenon when a single hip is replaced, this study shows that pulmonary reactions during bilateral THA may be different.
HSS is one of the few academic institutions with an extensive, interdisciplinary osteolysis research program. HSS Radiologists pioneered the pulse sequencing techniques that allow use of magnetic resonance imaging - despite the implant metal - to evaluate osteolysis in total hip arthroplasty. This recent study used the opportunity presented by osteolysis-caused revision surgery to compare the MRI signal changes indicating osteolysis to actual retrieved tissue.

MRI’s were taken of 17 patients undergoing revision THA. During surgery, tissue was obtained from specific anatomic sites correlating with indications of osteolysis observed on the MRI’s. The tissue and MRI images were then reviewed, blinded, by an experienced pathologist and radiologist, respectively.

Comparing the doctors’ results found that the MRI data correlated with measurements taken during surgery. These validated comparisons will help doctors and scientists continue to refine the non-invasive diagnosis of osteolysis and better monitor its progress and severity.
Patients with cerebral palsy (CP) are at risk for hip arthrosis, early onset of painful hip osteoarthritis, and loss of joint congruity. This study found that total hip replacement provides long-term relieved pain, improved function, and durable improvements for patients with CP.

56 patients (59 hips) with CP who had THAs for painful hips were reviewed. Average age of the patients at time of surgery was 30.6 years. The average time of follow-up was 9.7 years (range, 2–28 years). Chart review determined the preoperative, postoperative, and current functional levels. All patients or caregivers completed a questionnaire, including a modified Gross Motor Function Classification System mobility scale and qualitative reports of pain and satisfaction.

Pain levels were measured on a visual analog scale at three times: preoperative, postoperative, and current. Pain relief was obtained in all patients. All patients returned to preoperative function (59) and 52 patients returned to prepain functional status (88%). Seven patients underwent acetabular component revisions, and two patients had a femoral stem component revision. The 2-year implant survival was 95%, and 10-year survivorship was 85%.

Results show THA can provide durable relief and improved function in patients with CP with severe coxarthrosis.
Alternative bearing materials in THA have been developed to reduce the incidence of osteolysis. Alumina-on-alumina ceramic bearings exhibit extremely low wear rates but concerns exist regarding component impingement with the potential for dislocation and the occurrence of noise.

From the HSS Patient Registries, 436 alumina-on-alumina ceramic, cementless, primary THA’s in 364 patients were examined. At the average length of follow-up of 3 years 98% of the THA’s did not require a revision. Only 1.1% of THA’s - a total of 4 out of the 436 hips - had been revised for dislocation. Fewer than 2% of patients reported hearing an audible squeak, with no association found between component position and squeaking.

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Three Hydrocortisone Doses, Instead of Two, More Effective Against TKA Inflammation

An extra dose created lower IL-6 levels, less inflammation, less pain, and may even be more protective of lung injury.

Wear Damage in Mobile-bearing TKA is as Severe as That in Fixed-bearing TKA

Mobile-bearing TKAs did not improve wear damage.

Delaying Load Improves Tendon-to-Bone Healing

Delaying mechanical load and weight bearing movement after tendon-to-bone repair produced significantly better tendon-bone healing results in this study of 278 rats.

Implant Design Influences Tibial Post Wear Damage in Posterior-Stabilized Knees

How differences in implant design impact wear damage patterns and polyethylene wear debris.

Articulating Spacer with Autoclaved Femoral Component for Infected TKA: Minimum 6 Year Follow Up

Until now, very few studies have long-term results on this important technique.
During joint replacement one of the prime cellular messengers signaling the immune system to start and maintain inflammation is the cytokine protein IL-6. Rising levels of IL-6 can indicate infection, and have been linked to acute respiratory distress syndrome, postoperative confusion, depression, and fever.

Preventing IL-6 from rising and sending inflammatory signals helps reduce TKA infection and other deleterious outcomes. That’s why two doses of the steroid hydrocortisone are usually administered during total knee replacement. Hydrocortisone prevents IL-6 levels from rising.

In a recent double-blind study, HSS tested adding a third dose of hydrocortisone. Results showed the extra dose created lower IL-6 levels less inflammation, less pain and may even be more protective of lung injury.

28 knees in patients undergoing bilateral total knee replacement (BTKR) were divided into two groups: patients who received the standard two hydrocortisone doses (control group) and patients who would receive three doses (study group.)

Peak IL-6 levels at 24 hours were four times higher in the two-dose control group. Pain scores measured as visual analog scores were significantly lower in the three-dose study group, as was the incidence of fever (p=0.03). Range of motion at the knee was statistically higher in the study group (p=0.04). Urine desmosine levels – an elevated level of which HSS has found to be a potential indicator of lung injury in TKA – doubled by 24 hours in the control group, but remained unchanged in the three-dose study group. No infection was noted in any patient three months postoperatively.
Delaying mechanical load and weight bearing movement after tendon-to-bone repair produced significantly better tendon-bone healing results in this study of 278 rats.

All the rats underwent unilateral patellar tendon detachment and repair followed by placement of a custom-designed external fixator. The rats were then assigned to three groups for treatment after surgery: 1) immobilization, 2) immediate postoperative loading, or 3) delayed onset loading - either a 4 or 10-day delay.

Immobilized animals had significantly better mechanical results than the immediate-loading and-delayed loading groups. The immobilized animals also had less fibrocartilage, better collagen fiber organization at 4, 10, and 21 days, and decreased expression of MMP-13 at 10, 21, and 28 days.

The research team’s on-going studies of the impact of load on tendon-to-bone repairs can eventually help determine the timing, kind, and amount of physical therapy, as well as return to activities, that can best facilitate healing of tendon repairs, such as rotator cuff repair.

Carolyn M. Hettrich, MD, MPH, won the Lewis Clark Wagner Award for excellence in orthopaedic surgery research by an HSS resident for this study.
Wear Damage in Mobile-bearing TKA is as Severe as That in Fixed-bearing TKA

While mobile-bearing total knee implants reportedly have no clinical superiority over fixed-bearing TKAs, this study sought to answer whether a potential benefit might be improved polyethylene wear behavior in the mobile-bearing implants. They did not.

48 mobile-bearing total knee implants retrieved due to osteolysis, loosening, infection, stiffness, instability or malpositioning were studied and microscopically graded. Marked wear damage occurred on both surfaces of the implants, predominantly burnishing, scratching, and pitting. Damage occurred over a large portion of the surfaces, exceeding the available articular borders in nearly 30% of implants.

Wear of mobile-bearing surfaces included marked third-body debris. Increased patient size did not correlate with increased damage, but length of implantation did. Damage was also greater in implants removed for osteolysis or instability than in those removed for stiffness or infection.

Mobile-bearing TKAs did not improve wear damage, providing another argument against the superiority of these implants over fixed-bearing implants.
A study of 11 matched pairs of retrieved TKA implants has shown that femoral components made of oxidized zirconium (OxZr) exhibited less damage than the same components made from conventional cobalt/chrome/molybdenum alloy (CoCrMo).

56 retrieved total knee implants with conventional CoCrMo femoral components were matched in pairs with OxZr component implants according to duration of implantation, reason for revision, and patient age and body-mass-index. Polyethylene (PE) inlays and femoral components were optically scored for in vivo damage. Results showed that OxZr femoral components were less sensitive to in vivo damage.

The average damage score of the tibial PE inserts was also significantly lower with OxZr components ($p = 0.01$). Mainly burnishing and scratches were found. The average wear score in the visual analysis of the femoral components was significantly lower for the OxZr as well ($p = 0.005$).
As part of its extensive knee replacement design program, HSS frequently investigates wear patterns in existing implants to help guide effective innovation in new HSS implant design. Using the hospital’s database archive of over 16,000 retrieved implants, studies can examine particular issues that new designs can solve.

A recent collaborative analysis by HSS surgeons, scientists, and bionengineers of the polyethylene insert component of 274 retrieved total knee implants suggests design is the primary determinant of wear patterns, especially wear damage, in three primary kinds of existing knee implants. Length of implantation and revision diagnosis impacted wear, but to a lesser degree than the implant’s design itself.

Three different designs of posterior stabilized total knee implants were studied. The tibial post component of each design varied by shape, location, and relation to the tibiofemoral bearing surfaces.

Researchers were interested in how the differences in implant design might impact wear damage patterns and polyethylene wear debris. All 274 implants exhibited wear damage, however, the total wear scores on the anterior post differed among designs. One design exhibited more anterior wear, another more global wear, and the third predominately posterior wear damage.

The constraint provided by the posterior-stabilized post-cam contact in these modern knee replacements is reflected in the wear damage patterns created when the retrieved implants were in use. Unintended constraint such as anterior impingement should be addressed through design modifications for future posterior-stabilized knee implants.
A two-stage re-implantation technique that utilizes an articulating spacer for addressing infected total knee replacements results in effective treatment of infection and excellent range of knee motion, both between the two stages and at long-term follow up. Until now, very few studies have long-term results on this important technique.

During 1997-2004, seventeen patients whose total knee replacement had become infected underwent the two-stage procedure.

Patients were assessed at a minimum of six years (mean 94 months; range: 73-144 months) post reimplantation, and modified HSS knee scores were calculated. Results were very good. 15 of the 17 patients had no reinfection. (Two patients with diabetes had refractory re-infection, both more than two years after the re-implantation procedure.)

Average range of motion for those with no re-infection just prior to re-implantation was 4 degrees to 110 degrees, and 3 degrees to 112 degrees at latest follow up. HSS scores for those with no re-infection averaged 80 points (Range: 60-100) at latest follow up.

The re-infected patients were a woman with multiple-resistant organisms, who subsequently required external fixation, fusion, then amputation. The other, a 320-pound diabetic man required two further explantations and re-implantations using this method.
Unique hydrogel implant demonstrated its ability to successfully restore contact mechanics as effectively as allografts.

Innovative Synthetic Meniscus Implant Matches Allograft Performance

New meniscus cartilage cells have been shown to successfully grow across an HSS-developed degradable, porous polyurethane scaffold system.

Evaluating PUR’s performance during frictional tests.

Meniscal Injury after Single Bundle ACL May Result in Recurrent Instability
A new study has found that large radial tears of the medial meniscus are not functionally equivalent to surgical removal of tissue by meniscectomies, as the residual meniscus continues to provide some load transmission and distribution functions across the joint.

Human cadaver knees, wired with a sensor right below the meniscus to measure contact pressure, were subjected to a range of identical weight loads by a knee simulator. The meniscus of each knee was in one of six different conditions: 1) intact 2) a radial tear involving 30% of the meniscal rim width, 3) a radial tear involving 60% of the width, 4) a radial tear involving 90% of the width, (5) having had a meniscectomy with an inside-out repair with horizontal mattress sutures, and 6) a partial meniscectomy.

Tests showed that tears by injury or cutting by surgery affect the meniscus differently. Peak contact pressure was not affected by radial tears involving up to 60% of the meniscal rim width. Radial tears involving 90% resulted in a posterocentral shift in peak-pressure location manifested by an increase in pressure in that quadrant of $1.3 \pm 0.5 \text{ MPa}$ at 14% of the gait cycle relative to the intact condition. However, a 90% tear repaired by an inside-out mattress suture did not restore the location of the pressure peak to that of the intact knee. Partial meniscectomy led to a further increase in contact pressure in the posterocentral quadrant of $1.4 \pm 0.7 \text{ MPa}$ at 14% of the gait cycle.

Deepening understanding of the different contact mechanics experienced by a torn, repaired, or intact meniscus will help surgeons performing meniscectomies decide where and how much of the meniscus to trim, smooth, or save. Expert decisions can make a difference in helping relieve pain as well as give the meniscus a better chance to heal.
A collaboration of HSS surgeons, scientists, and bioengineers, working with long-time research partner Cornell University and hydrogel experts Drexel University has been developing a novel synthetic meniscus implant. The fiber-reinforced, hydrogel-based implant has the potential to, one day, replace tissue-donor allograft repairs and uniquely adapt to fit the shape and size of the space of an individual meniscus.

Two recent tests of the unique implant demonstrated its ability to successfully restore contact mechanics as effectively as allografts.

Human cadaveric knees were subjected to physiological gait loads on a knee joint simulator. The knees were 1) intact, 2) meniscectomized, 3) meniscus re-implanted to simulate a ‘pseudo-allograft’, or 4 & 5) had their meniscus substituted with the hydrogel implant containing two different percent contents of polyethylene: 10% and 30%.

The contact mechanics of the two synthetic implanted knees – regardless of fiber content – matched that of the pseudo-allograft implanted knees. No repaired knees could restore normal joint contact pressure and area compared to the intact knee. The geometry and mode of fixation of the hydrogel-based implants are now being modified, so that their contact mechanics might improve upon that of allografts, by more closely mimicking the contact mechanics of an intact knee.
Unique Cartilage Scaffolding Promotes Meniscus Cartilage Growth

New meniscus cartilage cells have been shown to successfully grow across a unique HSS-developed scaffold system implanted in ovine knees. In a recent test, the novel degradable porous polyurethane scaffolding allowed new, healthy tissue ingrowth without harming the intact meniscus cartilage with which it articulates.

A collaboration of HSS surgeons, scientists, and bionengineers tested the scaffolding on 42 mature ewes. Each ewe was given a partial meniscectomy. 23 ewe knees were implanted with the novel scaffold system. 19 knees were left intact. Knees were examined by magnetic resonance imaging, gross inspection, and histologic inspection of the cartilage of the tibial plateau.

Earlier tests of the same scaffolding on ewes given complete meniscectomies had not produced the same results. Unlike that test, here, no cartilage damage occurred under the site of scaffold implantation. This was likely influenced by the rapid infiltration of cells and the dense tissue that formed within the scaffold.

As cartilage has long shown difficulty in growing across implanted repair scaffolding, the successful new growth results of this system with partial meniscectomies is very encouraging. Differing results with different size meniscectomies may indicate, that as HSS continues developing cartilage scaffolding, unique variations will be required for different cartilage conditions. Innovation and testing continues.

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In tests as a potential material for meniscus implants, porous polyurethane foams (PUR) has shown great promise in enabling infiltration of new cells and fibrocartilage formation. But its frictional behavior has not yet matched that promise. Like all potential implant materials, PUR must be able to withstand the friction of cushioning bones when performing in an actual knee as a meniscus implant.

This collaboration of surgeons, scientists and bionengineers sought to determine the mechanisms that cause frictional degradation of PUR by subjecting it to a range of frictional conditions. Articular cartilage was oscillated against PUR or stainless steel using phosphate-buffered saline (PBS) and synovial fluid as lubricants.

Following friction testing, cartilage and PUR samples were analyzed with environmental scanning electron microscopy and histological staining to determine changes in tissue morphology. PUR demonstrated distinct lubrication modes when assessed by stribeck-surface analysis. However, boundary mode lubrication was dominant in the cartilage–PUR interfaces, and the low-friction pressure-borne lubrication mechanism that intact joints require was absent.

Microscopy noted obvious wear, with disruption of the collagen architecture and concomitant proteoglycan loss in cartilage articulated against PUR. These data collectively point to the continued importance of establishing frictional properties as design parameters for implants and materials using PUR for soft tissue replacement.
One of the most common subsequent surgeries following ACL reconstruction is meniscectomy. The effect of progressive meniscal loss on knee stability after ACL reconstruction is unknown. The objective of this investigation was to determine the effects of meniscectomy on knee stability following single-bundle ACL reconstruction as measured by a navigated pivot shift examination.

Cadaveric knees underwent single bundle ACL reconstruction using either an anatomic or nonanatomic technique. Knee stability was assessed with the menisci intact and after progressive meniscal resection. A surgical navigation system was used to track kinematics. Nonanatomic single bundle ACL reconstruction failed to restore normal knee stability even with the menisci intact. Anatomic single bundle reconstruction performed well with the menisci intact, but progressive instability was detect with increasing loss of the menisci.

These data suggest that, in the setting of meniscus injury following successful single bundle ACL reconstruction, recurrent instability may develop.
How Age Affects Intercondylar Notch Dimensions in Children

Using the 314-patient pediatric MRI database at HSS, growth patterns and intercondylar notch dimensions were determined.

Bone Marrow Edema Patterns of the Knee in Symptomatic Pediatric Patients

MRI review shows that the majority of pediatric bone marrow edema patterns follow six specific patterns.

New Epiphysiodesis Technique Using Percutaneous Radiofrequency: A Pilot Study

A new, minimally-invasive technique using ablation to perform epiphysiodesis as part of limb-lengthening.

Correlation of Magnetic Resonance Imaging and Histologic Examination of Physeal Bars

The first study to validate the measurements of physeal bars calculated from MR images compared to actual physeal bars in a rabbit model.
Notch dimensions in young pediatric subjects have not been well characterized. Yet, a narrow intercondylar notch in a child’s knee joint, which can affect the size of the anterior cruciate ligaments that sit in the notch, has been implicated as a potential predisposition to ACL injuries.

Using the 314-patient pediatric MRI database at HSS, growth patterns and intercondylar notch dimensions were determined. A significant proportion of anterior notch width growth occurs prior to age 10. Males, in general, had wider notch dimensions than females. Significant change in notch dimensions was not observed after age 11.

Knowing childhood notch growth patterns is relevant when selecting graft size for ligament reconstruction. Statistically significant differences in notch dimensions also highlights the need for pediatric specific knee MRI protocols, with adequate through plane resolution, to allow for appropriate visualization of ligaments in young children.
Bone marrow edema patterns are found in symptomatic pediatric patients with relatively high frequency. Contributing to this frequency may be the high strength of pediatric knee ligaments and tendons relative to epiphyseal bone with which these tissues interact.

Using the HSS Pediatric MRI database and reviewing 314 MRI’s of patients aged 3 to 18, this collaboration of HSS surgeons and radiologists, found that the majority of pediatric bone marrow edema patterns follow six specific patterns. Classifying a patient’s edema in one of these pattern groups can help the clinician recognize the mechanism of injury and thus, associated pathology, and choose proper treatments.

The six pattern groups identified are 1) hyper-extension 2) anterior tibial translation, 3) patellar dislocation, 4) varus or valgus load, 5) direct contusion, and 6) extensor mechanism overload.

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A new, minimally-invasive technique, well-suited for children’s small tubular bones, uses radiofrequency ablation to perform epiphysiodesis. This pilot study, using a rabbit model, found the new procedure to be effective, reproducible, and reliable.

When children have uneven limbs, epiphysiodesis is a procedure that removes or alters the growth plate in the physis of the longer limb. This allows the shorter limb to “catch up” and the two limbs to become more equal in length. Techniques for epiphysiodesis have evolved over the years from the original open surgery requiring direct observation of the physis. Now, with this new minimally invasive technique, a narrow radiofrequency probe is inserted under the skin and uses heat to alter the physis.

In this study, epiphysiodesis was performed with the new technique on the tibia in one leg of 15 skeletally immature male New Zealand White rabbits. The rabbits’ other leg was left intact. A 22-gauge radiofrequency probe was inserted percutaneously (under the skin) and heated to 90 degrees centigrade for 4 minutes on the medial and lateral (1/2) of the physis. Five animals were sacrificed at 2, 6, or 12 weeks postoperatively. Tibia length was compared using Faxitron(R) radiographs and electronic calipers. Histology of the growth plate was assessed with light microscopy.

The new minimally invasive procedure successfully stopped leg growth. Differences in tibia length between 4.16 mm and 11.59 mm (average 7.86 mm) at 12 weeks were found. The proximal tibia physis closed radiographically and histologically in all animals by 12 weeks. Histologic analysis showed no evidence of articular cartilage injury.
After trauma - and more rarely from infection - children may develop a bony bridge known as a physeal bar on the growth plates of their bones. This bar may interfere with normal growth patterns and create uneven limb growth, or other complications. Being able to accurately measure and monitor a physeal bar through MRI’s, allows doctor’s to non-invasively determine any course of treatment.

This is the first study to validate the measurements of physeal bars calculated from MR images by comparing the image calculations with direct measurements made histologically of the actual physeal bar itself.

A physeal bar was created in the tibia of 18 immature rabbits, and 6 weeks after this surgery, MRI images of their knees were acquired. Because MR images are taken in multiplanar segments, they allow a “slice-by-slice” 3D reconstruction of the knee. In this study, researchers were able to compare both overall MRI measurements as well as each “slice” to actual histological measurements taken at matched points on the rabbit’s physeal bar and knee. A strong correlation (r=0.8) was found between the measurements, thus validating MRI accuracy for non-invasively conveying detailed knowledge of physeal bars in children.

The results provide a foundation for quantitative evaluation of in-vivo human physes and HSS’s ongoing establishment of pediatric-specific imaging and informational databases to aid diagnosis and treatment.
Diabetes Mellitus Impairs Tendon-Bone Healing After Rotator Cuff Repair

In discoveries that could ultimately have significant impact in the patient population, diabetes was found to delay tendon-to-bone healing in the repaired rotator cuffs of rats.

Larger Rotator Cuff Tears Create a Larger Inflammatory Response

The size of tears in patients’ rotator cuffs impacted both the amount of inflammation and tissue degeneration – larger tear, larger response.
A collaboration of HSS surgeons and scientists has found that diabetes delays tendon-to-bone healing in the repaired rotator cuffs of rats. These findings could have significant implications for the expected outcomes of soft tissue repair or reconstructive procedures in diabetic patients with poor glycemic control.

Forty-eight male, Lewis rats underwent unilateral detachment of the supraspinatus tendon of the rotator cuff followed by immediate anatomic repair with transosseous fixation. Half of the rats had diabetes induced before the surgery, half did not.

The diabetic animals demonstrated significantly less fibrocartilage and poorly organized collagen, and increased advanced glycosylation end-product (AGE) deposition at the tendon-bone interface (P < .05). The diabetic group also showed a significantly reduced ultimate load-to-failure (4.79 ± 1.33N vs 1.60 ± 1.67N and 13.63 ± 2.33N vs 6.0 ± 3.24N for control versus diabetic animals at 1 and 2 weeks, respectively) and stiffness compared to control animals (P < .05).

This study is the 2010 Basic Science NEER Award winner.
Larger Rotator Cuff Tears Create a Larger Inflammatory Response

The size of tears in patients’ rotator cuffs impacted both the amount of synovial inflammation and tissue degeneration in this study of biosamples from 24 patients having arthroscopic rotator cuff repair (15 full, 9 partial). Larger tear size meant larger response.

When comparing immune system response to rotator cuff tear size, larger tears produced larger expression of the pro-inflammatory gene IL-6, as well as more tissue remodeling by genes TIMP-1, MMP-1, and COL1A1, in the synovium surrounding the joint. This larger response occurred in spite of a wide diversity of samples, including gender, age, chronicity of tear, and size of partial thickness tears.

Findings also suggested that proinflammatory and neovascularization factors are closely associated with tendon remodeling and likely play a role in the pathogenesis of rotator cuff tears. Further studies will seek to determine how these responses might affect clinical outcomes.
Adhesive Capsulitis: Steroid Injection Brings Relief

How treating “frozen shoulder” – or adhesive capsulitis – with corticosteroids can shorten or reverse the disease process.

Effective Glenoid Version in Professional Baseball Players

Understanding shoulder mechanics during throwing activities and how they may differ between elite athletes and the average population.

Screw Fixation and Third-body Wear Associated with Osteolysis after TSA

Failed total shoulder arthroplasty (TSA) surgeries showed osteolysis significantly more present in patients whose implants used adjuvant screw fixation.

New Findings on Blood Supply to the Humeral Head

Posterior humeral circumflex artery found to provide 64% of the blood supply to the humeral head overall.
Understanding shoulder mechanics during throwing activities and how they may differ between elite athletes and the average population can help clinicians better address the unique needs of the professional baseball player.

Magnetic resonance imaging scans of the shoulders of 38 male professional baseball players (dominant shoulder of pitchers and fielders) and of 35 age-matched non-throwing control patients (17 dominant and 18 nondominant shoulders) were studied. Seven different measurements were made by 3 blinded reviewers on 3 axial images per patient: 1) version of superior glenoid, 2) middle glenoid, 3) inferior glenoid, 4) superior capsulolabral junction, 5) middle capsulolabral junction, 6) inferior capsulolabral junction, and 7) depth of concavity of glenoid in a middle slice.

Comparing shoulders within the professional ball players group found no significant statistical differences between the pictures and the fielders. And in the non-throwing control group, there were only 2 differences between dominant- and nondominant- shoulder patients: version of superior glenoid and depth of concavity of glenoid in a middle slice.

Comparing the two groups to each other, however, showed marked contrast. The athletes and the dominant shoulder segment of the control group differed significantly on all of the 7 measurements.

There was also significantly more retroversion in the osseous and soft tissues of the elite throwing athletes than the control patients. This increased retroversion may play a role in development of internal impingement in the overhead athlete.
Treating “frozen shoulder” – or adhesive capsulitis – with corticosteroids can shorten or reverse the disease process by decreasing the pathologic changes found in the shoulder’s capsular tissue.

A recent study of 20 patients with adhesive capsulitis demonstrated that intra-articular steroid injection decreased the presence and amount of fibromatosus, vascular hyperplasia, and fibrosis, in addition to decreasing the number and presence of fibroblasts staining for smooth muscle actin.

Those who were not treated with pre-operative corticosteroid demonstrated histologic evidence of more disease pathology (fibromatosis, synovial hyperplasia) and a higher proportion of specimens with positive staining for smooth muscle actin.

This quantitative analysis of myofibroblast proliferation showed that steroid injection is an effective and recommended treatment for frozen shoulder.

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Clinical, radiographic and histopathologic analysis of failed total shoulder arthroplasty (TSA) surgeries showed osteolysis significantly more present in patients whose implants used adjuvant screw fixation.

Glenoid implants from 52 TSA revision surgeries conducted from 1985 to 2005, were divided into two groups: implants from patients who had developed osteolysis (n=10) and implants where osteolysis was not present (n=42). Clinical information, associated histopathology from tissues obtained at revision surgery, and polyethylene wear data from the retrieved glenoid components were compared between groups.

Results showed that of the implants in the osteolysis group, 20% had screw fixation. Only 2.5% of the implants in the group without osteolysis used screw fixation. (P = .039)

The radiolucency score was significantly higher in the osteolysis group: 12.7 +/- 2.0 vs 8.7 +/- 3.7 (P = .003). Wear analysis of the osteolysis group demonstrated significant increases in third-body particles compared with those implants without osteolysis (P = .004). Histology available from retrieved implants demonstrated particulate debris in 62% of patients with osteolytic lesions vs 67% without osteolytic lesions, basically no difference, despite the prevailing notion that osteolysis is associated with particulate debris from implant wear.
Fractures of the proximal humerus bone occur frequently as a result of elderly patients falling. When these fractures fail to heal properly, the site of most nonunions is in the humeral shaft, closer to the shoulder, within the proximal one-third of the diaphysis.

Until now, no study has reviewed the management of nonunions of the proximal diaphysis to assess treatment strategies for these difficult fractures.

The clinical and radiographical data of 19 patients with nonunions of the proximal humeral diaphysis were studied. Their mean age was 70 (range 29-94 years). They represented 46% of all humeral shaft nonunions treated during the study period.

In 11 cases, the nonunion was addressed with dual plating to get adequate fixation in the proximal segment. Post-operative alignment was within 5° of anatomic in all cases. All the nonunions healed at an average of 15.2 weeks (range 8-36 weeks). The mean length of follow-up was 12.5 months (range 6-122 months). All patients reported significant improvement in pain. The mean range of motion following fracture union was forward flexion 137°, external rotation 41° and internal rotation 30°. There were two minor complications and neither required a secondary surgery.

The surgical technique used emphases a thorough debridement of the nonunion site, correction of the deformity, fracture site compression with a rigid construct and bone grafting provides excellent rates of union and clinical outcomes.
New Findings - Blood Supply to the Humeral Head Proportioned Differently than Widely Assumed

Until now, it has been commonly thought that the main blood supply to the humeral head of the shoulder was provided by the anterior humeral circumflex artery. Yet, even though that artery is disrupted in 80% of fractures of the proximal humerus, the resulting osteonecrosis – bone death by lack of blood supply – that could be expected to happen infrequently occurs.

Collaborators at HSS investigated this inconsistency and discovered that the blood supply to the humeral head is not as reported in the literature. Another artery – the posterior humeral circumflex artery – appears to actually supply 64% of the blood supply to the humeral head. It also provided significantly more of the blood supply in three of the four quadrants of the humeral head.

The investigators used 12 pairs of cadaveric shoulders. One shoulder in each pair was left intact as a control. In the other shoulder either the anterior humeral circumflex artery or the posterior humeral circumflex artery was ligated. Gadolinium was injected through the cannulated axillary arteries, and magnetic resonance imaging was performed. After imaging, a urethane polymer was injected, and specimens were dissected. For volumetric analysis, the gadolinium uptake on the magnetic resonance imaging was quantified in each quadrant of the humeral head with use of a custom automated program. The gadolinium uptake was compared between the control and ligated sides and between the ligated anterior humeral circumflex artery and ligated posterior humeral circumflex artery groups.
New Model Allows Study of Lumbar Spine Mechanics in Rats Over Time

Now, a new, non-invasive test allows long-term spinal studies of the same animal, over time, opening new possibilities in spinal research.

Risk Factors for Surgical Site Infection Following Instrumented Spinal Fusion

A review of 3218 patients who received posterior lumbar fusion patient identifies new risk factors for surgical site infection. Until now, investigations have not used such large numbers to identify potential causes.

Gene-Delivery Induced Intervertebral Disk Neoangiogenesis and Anterior Spine Fusion

New method of delivering growth factors to spinal fusion through gene mediated tissue engineering.
Now, valuable studies of spinal conditions in rodent lumbar and caudal (tail) spine segments can be conducted over the long term, because a new, noninvasive induced angular displacement (NIAD) test delivers accurate results without requiring rat euthanasia.

To validate the new test, Lewis rats were measured two ways: with the new test, and in the older, actual measurements of euthanized animals. First, anesthetized Lewis rats were xrayed in a 90° angled fixture, and NIAD measurement was taken and assessed at lumbar levels L4 to S1 by two independent and blinded observers.

After euthanasia, in vitro angular displacement (IVAD), stiffness, and failure moment were measured for the combined L4-L6 segment in four-point bending. Comparisons showed that the new NIAD method yielded reproducible and reliable rat lumbar spine angular displacement measurements without required euthanasia. This allows repetitive monitoring of the same animals, who can be studied over time, opening new possibilities in spinal research.
New potential independent risk factors for infection after spinal surgery were identified in an extensive review of patients who underwent instrumented posterior lumbar fusions. The study included 3218 posterior lumbar fusion patients. Osteoporosis, chronic obstructive pulmonary disorder and intraoperative dural tears were identified as potential risk factors for surgical site infection. Until now, investigations have not used such large numbers to identify potential causes.

The overall rate of post-surgical infection was 2.61% (85 infections in 3,218 operations). The most common pathogen isolated from patients’ wounds was MRSA. Multivariate analysis confirmed obesity as a unique risk factor, separate from others. Diabetes is also an independent risk factor. Coronary heart disease elevates infection risk. Revision surgery does not.

Patients being treated for osteoporosis and chronic obstructive pulmonary disorder were also more likely to experience surgical site infection. The conditions may represent factors unique to the posterior lumbar approach to spinal fusion.
Gene-Delivery Induced Intervertebral Disk Neoangiogenesis and Anterior Spine Fusion

Ongoing investigations at HSS are examining the use of growth factor proteins in spinal fusion to speed and enhance formation of new bone. Collaborations of HSS surgeons and scientists have used adenovirus to deliver two growth factors – bone morphogenetic protein (BMP) 2 and BMP7 – to the intervertebral disk (IVD) in rats’ spines. The IVD is a site on the skeleton where bone fusion surgery commonly is induced clinically, to help control back pain symptoms. Other growth factors that HSS researchers have used include vascular endothelial growth factor (VEGF).

Recently, collaborators investigated a new method of delivering growth factors to spinal fusion: through gene mediated tissue engineering. The team’s study showed that gene-delivery is possible, and that tissue engineering experiments including gene-delivery can make the rat’s avascular IVD “permissive to neoangiogenesis”. Which means “ready to begin the process of making new blood vessels”. The investigators are very enthusiastic that this finding may mean that the IVD will be able to be made permissive to neoosteogenesis, which means “ready to begin the process of making new bone”.

In the most recent study using the gene delivery method, investigators sought to determine if: 1) inducing a blood supply inside the IVD (with gene delivery of VEGF) would permit new bone cell formation when a co-treatment of BMP was also added and (2) if chemical destruction of the IVD with purified chondroitinase ABC (chABC) would make the IVD permissive to BMP’s induction of new bone cell growth. *(continued, tap here)*
Rats were divided into nine treatment groups: 1) no surgery (mock), 2) delivery of naïve cells, 3) delivery of VEGF expressing cells, 4) delivery of BMP2/7 expressing cells, 5) delivery of purified chABC, and 6-9) all combinations of the 3 treatments.

Spinal mobility decreased in all groups, but was most apparent in the BMP and BMP/VEGF group. Abundant bone production primarily occurred in the BMP and BMP/VEGF groups, but not in the others. The data also suggests that chABC interfered with new bone production as all treatment groups with chABC had much lower new bone formation, possibly by its effect on early osteoid and matrix production.

Gene delivery of growth factors that encourage new bone growth may be possible, but more research will be needed to understand the best ways how to achieve that goal. The range of findings underscore the complex physiology of the IVD as regards to maintaining homeostasis, and the issues to be addressed in the future.

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