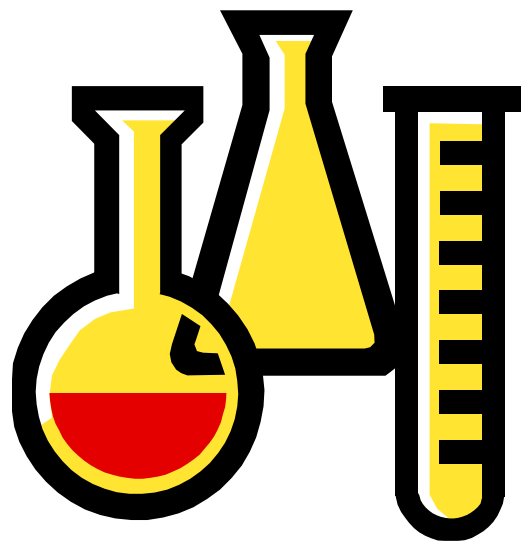


THE OHIO STATE UNIVERSITY

Department of Orthopaedics

30th Annual
Mallory-Coleman
Resident Research Day



Friday, April 12, 2002

JL Camera Center
2050 Kenny Rd

PROGRAM

- 7:30 am Refreshments
- 7:45 am Welcome and Introduction
- 8:00 am ***RAY WASIELEWSKI, M.D.***
"The Results of Intraoperative Computer Documented Ligament Balance Correlated with Postoperative Fluoroscopic Analysis in TKA Patients"
- 8:15 am ***RYAN KLINEFELTER, M.D.***
"Torsional Yield Strength of Femoral Step-Cut Osteotomies Stabilized with Intramedullary Nailing"
- 8:30 am ***THOMAS MALLORY, M.D.***
"Is the Modularity of the S-ROM Stem a Disadvantage or an Advantage?"
- 8:45 am ***RHONDA APER, DVM***
"Fatigue Study of 2.7 mm Cortical Screws Used in a 6 mm Diameter Interlocking Nail"
- 9:00 am ***RICK JENNINGS, DPM***
"A Comparative Analysis of the Use of Internal Fixation with Chevron Osteotomies of the First Metatarsal"
- 9:15-9:30 Break
- 9:30 am ***ALICIA BERTONE, DVM, PH.D.***
"Adenoviral-Mediated Transfer of hBMP-6 Gene Accelerates Osteotomy Repair"
- 9:45 am ***CHRISTOPHER NEHER, M.D.***
"A New Reduction Technique for Severely Displaced Pediatric Radial Neck Fractures"
- 10:00 am ***ROSS PASKOFF, M.D.***
"Comparison of Mode of Failure and Failure Strength of Arthroscopic Suture Anchors"
- 10:15 am ***JOHN BREM, DPM***
"Comparison of Suture Anchors in Dense Polyurethane Foam"
- 10:30 –10:45 Break
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PROGRAM, CONTD

- 10:45 am ***VICTOR GOLDBERG, M.D., VISITING PROFESSOR AND MODERATOR***
"Biological Restoration of Articular Cartilage"
- 11:45-12:45 *Lunch*
- 12:45 pm ***CHRISTOPHER NEHER, M.D.***
"Treatment of Subtrochanteric Femur Fractures Using a Submuscular Fixed Low-Angle Plate"
- 1:00 pm ***TIM REISH, M.D.***
"Ipsilateral Sliding Hip Screw and Retrograde Intramedullary Nail: A Biomechanical Comparison of Constructs"
- 1:15 PM ***WILLIAM McDONALD, M.D.***
"The Anatomy and Isometry of the Medial Patellofemoral Ligament: Implications for Reconstruction"
- 1:30 pm ***TINA DEMOU, DPM***
"Buechel Pappas™ Total Ankle Replacement System Study: A Short-term Data Analysis"
- 1:45 pm ***ERIC PRENGER***
"Micromotion Measurement in Articulating Hip Prostheses: an *in vitro* analysis"
- 2:00 pm ***CHRIS O'SULLIVAN, DVM***
"Laser Shock Peening Increases Fatigue Life of Cortical Bone Screws"
- 2:15 PM ***CHRISTOPHER KAEDING, M.D.***
"Intra-articular Findings in the Multiligament Injured Knee"
- 2:30 PM *End of Day*
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**MALLORY-COLEMAN
DAY**

Mallory-Coleman resident research day was established in 1972 in memory of Katherine Virginia Mallory and Sally Jo Coleman.

This research day was established in order to encourage the development of ideas related to research in orthopaedic surgery and basic science. In accordance with the curriculum for both the OSU Orthopaedic and Podiatric residency programs, each chief resident is required to present his or her research project during this forum.

Each year, a distinguished visiting professor from an outside institution is invited to moderate and analyze the resident presentations and abstracts as well as provide constructive criticism and commentary for each resident presentation.

Past Visiting Professors Include:

- 2001 James Urbaniak, M.D.
- 2000 Douglas Jackson, M.D.
- 1999 Douglas Dennis, MD
- 1998 Thomas Einhorn, MD
- 1997 Larry S. Matthews, MD
- 1996 Gary Friedlander, MD
- 1995 James Herndon, MD
- 1994 Clement B. Sledge, MD
- 1993 Eric L. Radin, MD

**2002 MALLORY-COLEMAN
VISITING PROFESSOR AND
MODERATOR:**

VICTOR GOLDBERG, M.D.



Dr. Goldberg has been the Chairman of the Department of Orthopaedics at Case Western Reserve University since 1989. He was Vice-Chairman of the Department from 1982—1988. He is also currently the Charles H. Herndon Professor in the Department of Orthopaedics at Case Western.

He received a bachelors degree from New York University College of Arts and Sciences in 1960. He went on to receive a Doctor of Medicine degree from the State University of New York—Downstate Medical Center in 1964. He continued his education with a residency in orthopaedics at the Hospital for Special Surgery in New York. Dr. Goldberg also completed fellowships in Surgery at both Western Reserve University School of Medicine and the Hospital for Special Surgery.

He served as a captain in the United States Air Force from 1966—1968, where he was Chief of Surgery at Blytheville Air Force Base and later Chief of Professional Services.

He is currently board certified in orthopaedic surgery and is a diplomate of the National Board of Medical Examiners.

Over the course of his career, Dr. Goldberg has served on the editorial board of several orthopaedic journals such as Clinical Orthopaedics and Related Research, the Journal of Bone and Joint Surgery, and the Journal of Arthroplasty. He has also served on numerous national and local committees and task forces, such as the Advisory Committee on Research, American Academy of Orthopaedic Surgeons, of which he has served as chairman. He has also served as vice president of the Council of Clinical Chairman.

He is currently a member of over 20 honorary and professional societies. He has contributed over 20 book chapters to the medical literature and has published over 170 journal articles and 140 abstracts.



Ray Wasielewski, M.D. is an Associate Professor of Orthopaedics and Director of the Division of Total Joint Replacement at The Ohio State University

THE RESULTS OF INTRAOPERATIVE COMPUTER DOCUMENTED LIGAMENT BALANCE CORRELATED WITH POSTOPERATIVE FLUOROSCOPIC ANALYSIS IN TKA PATIENTS

Authors: Ray Wasielewski, M.S., M.D., Richard Komistek, Ph.D.

Presenter: Ray Wasielewski, M.D.

Fluoroscopic analysis has recently been used to analyze the kinematics of total knee arthroplasty (TKA). These analyses have reported varying results even in patients with similar implant design. This study was done to correlate intra-operative computer assessed compartment pressures with postoperative kinematics to establish correlations that explain these kinematic variations.

Sixteen patients were implanted with a posterior cruciate sacrificing (non-ps) LCS TKA utilizing a balanced gap technique. After optimal knee balance was obtained using a balanced gap technique, compartment pressure and balance were ascertained utilizing intraoperative computer sensors placed on the surface of the tibial insert trial. With trials and sensor in place, the knee was taken through a range of motion from 0 – 120. The magnitude and location of compartment pressures was documented throughout this range. Normal perioperative protocols for TKA were instituted, including 3 to 6 weeks of physical therapy. Postoperatively all patients performed successive weight-bearing deep knee bends while under fluoroscopic surveillance to maximum flexion. Femorotibial contact positions and liftoff values were assessed using video fluoroscopy. Each subjects' fluoroscopic data was correlated to intraoperative compartment pressure findings at trial arthroplasty to establish correlations.

Fluoroscopic results correlated closely with intraoperative soft tissue balance and compartment pressures. Only 3 of the 16 patients had lift-off and all experienced lift-off at only one flexion angle. All three of these patients had a compartment pressure imbalance as measured by the intraoperative computer at the same flexion angle as the liftoff occurred experienced condylar lift-off at the same flexion angle. Other subjects having similar compartmental pressures of both condyles, derived using the intraoperative computer balancing process, did not experience condylar lift-off values greater than the process error of 0.5 mm. Only 3 of 16 patients experienced opposite axial rotation with flexion (abnormal posterior sliding of the medial condyle and anterior sliding of the lateral condyle with flexion). Paradoxical anterior sliding of the femur on the tibia with flexion averaged only 0.5mm from the dwell point.

This study determined that there is a strong correlation between surgical technique and fluoroscopic findings of liftoff and femorotibial translations. The balanced gap technique produced excellent gap balance resulting in TKA's with little liftoff and very good translational and rotational data relative to previously reported kinematics studies on the LCS knee. This suggest that while a given implant design may have inherent kinematic tendencies, surgical technique significantly impacts kinematic performance. Therefore, it may be important for surgeons to accurately balance the flexion and extension gaps to optimize implant kinematics and subsequent function and longevity.



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TORSIONAL YIELD STRENGTH OF FEMORAL STEP-CUT OSTEOTOMIES STABILIZED WITH INTRAMEDULLARY NAILING

Authors: Ryan D. Klinefelter, M.D., Joel Mayerson, M.D., Alan Litsky, M.D., ScD.,
Tom Smith, B.S.

Presenter: Ryan Klinefelter, M.D.

Background

Due to advances in multidisciplinary treatment, patients with malignant tumors of bone currently have an excellent prognosis for long-term survival. Five-year survival rates have improved from less than 20% in the 1970's to approximately 70% today. Limb salvage has become the accepted standard in the United States for treatment of malignant tumors of the pelvis and extremities. Patients who present with malignant diaphyseal tumors are in need of a durable method of reconstruction that will allow them to function at the highest possible level. Traditionally, reconstruction consists of an intercalary prosthesis or of an intercalary allograft stabilized with plating or intramedullary nailing. With intramedullary nailing, a step-cut osteotomy assists the interlocking bolts of the nail in providing rotational stability. Convention has been to make a 10 mm step-cut. This study is designed to evaluate the proper length of the step-cut osteotomy to provide maximal torsional stability without significantly weakening the allograft or host bone.

Materials and Methods

Twelve cadaveric femora were obtained from an anatomy lab at a regional medical school. All femurs were free of mechanical devices, deformity, and gross disease as determined by visual and radiographic examination. The femora were randomly assigned to one of three groups consisting of four femora. Group A had a step-cut length of 5mm. Groups B and C had step-cut lengths of 10 and 15 mm, respectively. All femora were then reamed through a standard piriformis fossa starting point up to 12.5 mm. The step-cuts were then created 10 cm below the lesser trochanter. The intramedullary nails (model CFX Alta, diameter 11 mm, length 300/320 mm, Howmedica, Rutherford, New Jersey) were then placed using 2 proximal screws (6.5 mm X 85/90 mm). Distal interlocking bolts were not placed. The proximal and distal ends of the femur were secured to a load cell actuator of an MTS 858 Bionix servohydraulic material test frame (MTS Systems, Eden Prairie, MN). A rotational force of one degree per second under constant load of 700 N was applied. Torque values at failure were measured.

Results

All constructs failed at the step-cut site. The mean torque at failure for the constructs in group A was 16.1 N·m. Groups B and C failed at a mean torque of 12.8 N·m and 15.3 N·m, respectively. ANOVA testing demonstrated no statistically significant difference between the groups ($p=0.61$).

Conclusion

The length of the step-cut has no statistically significant effect on the torsional failure strength of a step-cut osteotomy in a cadaveric femur model.



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IS THE MODULARITY OF THE S-ROM STEM A DISADVANTAGE OR AN ADVANTAGE?

Authors: Thomas H. Mallory, M.D., Adolph V. Lombardi, Jr., M.D.
Presenter: Thomas H. Mallory, M.D.

Stem modularity is thought to improve intraoperative customization of femoral components in order to treat the distorted anatomy of the diseased hip and achieve optimum fit and fill in cementless total hip arthroplasty. Although this has been shown to be beneficial in revision hip arthroplasty, the role of stem modularity in primary total hip arthroplasty is less clear. This study evaluates the use of modular-stemmed Sivash Range of Motion femoral components (S-ROM; formerly Joint Medical Products, now DePuy, a Johnson and Johnson Company; Warsaw, IN) in comparison with non-modular-stemmed Mallory-Head Porous femoral components (MHP; Biomet; Warsaw; IN) in patients undergoing primary cementless total hip arthroplasty. From November 1987 to February 1994, three surgeons implanted 265 S-ROM components in 216 patients and 233 MHP components in 201 patients. All femoral components were titanium with modular femoral heads of either chrome cobalt or ceramic. A variety of acetabular components were utilized. Demographics of the two groups were statistically similar. Average age was 46 years in the S-ROM group and 50 in the MHP group. In terms of gender, the S-ROM group had 122 male patients (58%) and 90 female patients (42%), and the MHP group had 119 male patients (59%) and 82 female patients (41%). Body mass index averaged 2.8 pounds per inch for the S-ROM patients and 2.9 pounds per inch for the MHP patients. Osteoarthritis, the most common diagnosis for both groups, was noted for 58% of cases in the MHP series and 50% in the S-ROM series. Patients were assessed clinically utilizing the Harris hip score. Radiographs were analyzed for stability of fixation and presence of osteolysis. Clinical follow-up averaged 73 months for the S-ROM group and 60 months for the MHP group. Harris hip scores improved by an average of 44 points in the MHP group and 46 points in the S-ROM group ($p=0.6$). Operative time averaged 49 minutes (± 14) in the MHP group and 67 minutes (± 24) in the S-ROM group ($p<0.0001$). Intraoperative blood loss averaged 265 cc (± 106) in the MHP group and 299 cc (± 150) in the S-ROM group ($p=0.004$). Radiographs revealed stability of fixation in all femoral components in the MHP group and in 98.5% of the S-ROM group. Four S-ROM femoral components (1.5%) and no MHP femoral components have been revised due to aseptic loosening. A pattern of osteolysis extending from the level of neck resection into the greater trochanter was seen radiographically in 10% of the S-ROM cases while no femoral osteolysis was seen in the MHP group ($p<0.0001$). Nine acetabular components in the MHP series and 34 in the S-ROM series have been revised due to aseptic failure ($p=0.0007$). This study documents similar clinical and radiographic results with both the modular S-ROM and non-modular MHP femoral components in primary cementless total hip arthroplasty, emphasizing that stem modularity is not essential in order to achieve stable fixation. Optimum fit and adequate stability can be achieved using a tapered monolithic stem. Moreover, modularity can make the procedure more surgically demanding and invite problems such as third body wear.



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FATIGUE STUDY OF 2.7 MM CORTICAL SCREWS USED IN A 6 MM DIAMETER INTERLOCKING NAIL

Authors: Rhonda Aper, DVM, Kenneth A. Johnson, DVM, Alan S. Litsky, M.D., Sc.D, S.C. Roe

Presenter: Rhonda Aper, DVM

The purpose of this study was to determine the fatigue strength of 2.7 mm diameter cortical bone screws currently used in the 6 mm interlocking nail. The effects of bone diameter and eccentric loading of the screw on fatigue strength were examined. The authors hypothesized that the fatigue strength would 1) decrease with an increase in the diameter of the bone, and 2) increase with eccentric loading of the screw.

Locking screws were tested in cyclic three point bending for fatigue strength. A simulated bone model using aluminum tubing and a 6 mm diameter interlocking nail were used to cyclically load each screw in three-point bending. Each screw was cycled at a rate of 10 Hz, with a peak load of 300 N reached during each cycle. The number of cycles until implant failure was recorded. Three groups of screws were tested with 6 screws in each group. Group 1: 2.7 mm cortical screws centrally loaded within 19 mm (3/4") diameter aluminum tubing. Group 2: 2.7 mm cortical screws centrally loaded within 31.8 mm (1 1/4") diameter aluminum tubing. Group 3: 2.7 mm cortical screws loaded an offset distance of 5.5 mm (7/32") from center in the 31.8 mm diameter aluminum tubing. Data were examined to determine the effect of bone diameter (Group 1 vs. Group 2) and eccentric loading (Group 2 vs. Group 3).

An increase in the diameter of the aluminum tubing from 19 mm to 31.8 mm resulted in a significant decrease in the number of cycles to failure ($761,215 \pm 239,853$ and $16,941 \pm 2,829$, respectively). Eccentric loading of the locking screw resulted in a significant increase in the number of cycles to failure ($16,941 \pm 2,829$ and $43,068 \pm 14,073$, respectively).

Within a bone, locking screws are subjected to different loading conditions depending on location (diaphyseal vs. metaphyseal). The results of this study indicate that the fatigue life of a locking screw centrally loaded in the metaphyseal region of bone may be significantly shorter than in the diaphysis. Eccentric loading of the locking screw in the metaphysis may help to improve its fatigue life.



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A COMPARATIVE ANALYSIS OF THE USE OF INTERNAL FIXATION WITH CHEVRON OSTEOTOMIES OF THE FIRST METATARSAL

Authors: Rick Jennings DPM and Alan Litsky M.D., Sc.D.
Presenter: Rick Jennings, DPM

The purpose of this study was to determine if there was any difference in stability between Chevron osteotomies utilizing internal fixation versus osteotomies. Several references support the concept of the inherent stability obtained with the traditional 60 degree Chevron osteotomy. It has become increasingly popular among surgeons to use a modification of the Chevron osteotomy, which extends the dorsal arm by decreasing the angle of the cut to 55 degrees. In this study thirty-five osteotomies were performed on synthetic analogs of the first metatarsal utilizing the Chevron osteotomy with various methods of fixation. Ten of the osteotomies went unfixed to establish a control. Ten osteotomies were fixed with 1.5 mm Smartnails, ten by 3.0 mm Vilex cannulated screws and five by Synthes 3.0mm cannulated screws. The osteotomies were positioned with the apex of the cut at the center of the metatarsal head and angulated at 55 degrees following a 3mm lateral shift of the capital fragment. The constructs were testing in three point dorsal-plantar bending at a displacement of 10N/sec. Both Vilex and Synthes outperformed the Smartnail and the control. The peak bending force for the Vilex fixed metarsals was a mean of 583N and the mean peak load using the Synthes screws was 504N. Unfixed metatarsals failed at a mean of 313N and the Smartnails pulled out of the proximal fragment at 222N. There was no statistical difference between the Vilex screw and the Synthes screw when compared in three point bending. There was also no statistical difference between the Smartnail and the control. If it is the intention of the surgeon to institute immediate post-operative weight-bearing then rigid internal fixation utilizing a screw should be the method of choice.



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ADENOVIRAL-MEDIATED TRANSFER OF hBMP-6 GENE ACCELERATES OSTEOTOMY REPAIR

Authors: Alicia Bertone, DVM; D. Pittman, DVM; M. Bouxein, DVM; J. Li, DVM; B. Clancy, DVM; H. Seeherman, DVM
Presenter: Alicia Bertone, DVM, Ph.D.

Hypothesis:

Percutaneous injection of adenoviral vector encoding human bone morphogenetic – 6 [Ad-hBMP-6] protein into an osteotomy of the rabbit ulna will accelerate osteotomy healing.

Introduction:

BMP-6 is a member of the TGF- β superfamily of structurally related proteins that was first identified in extract of bovine demineralized bone and determined to regulate the differentiation of osteochondral progenitor cells through the activation of receptor-regulated Smads and autocrine feedback with other growth and differentiation factors such as *ihh*. BMP-6 induced the same set of genes (*ihh*, *noggin*, type X collagen, and endogenous BMP-6) as BMP-2 in chondrocytes in vitro, but did not upregulate the expression of TGF- β inducible early gene (TIEG) in a human immortalized fetal osteoblast (hFOB) which generally correlated with the proposed osteoinductive capacity of these cytokines (TGF- β >>>BMP-2>BMP-4>activin>>BMP-6. BMP-6 bone forming activity has not been evaluated in vivo due to limited quantities of BMP-6, although a recent study did demonstrate BMP-6 protein accelerated cartilage calcification in vitro. Adenoviral vectors can efficiently deliver transgenes to repair cells, induce protein production in vivo, and be used for screening of functional biologic activity. Unpublished preliminary studies of the intramuscular injection of Ad-BMP-6 in the quadriceps of mice and rats suggested a potent osteoinductive response in vivo that was threshold dose dependent, but the efficacy of local gene delivery in a bone injury was not investigated in a larger, relevant model. The goal of this current study was to evaluate the quantitative, qualitative, and functional bone formation induced by local BMP-6 delivery at a fracture site using adenoviral-mediated BMP-6 gene transfer in an osteotomy fracture model in vivo.

Materials and Methods:

Adenoviral vector generation – hBMP-6 cDNA was cloned from human placental and brain cDNA libraries. The full-length clone defines a 1539 base-pair open reading frame that encodes the 513-amino acid hBMP-6. HBMP-6 cDNA was subcloned into an expression vector (Ad ori 1-1) and co-transfected with a plasmid containing the 9-36 map units of Ad5 into receptive human embryonic kidney 293 cells to produce infectious adenoviral particles containing hBMP-6 transgene.

Preliminary Studies – Rabbits (n=3) had bilateral ulna osteotomies performed under general anesthesia. One limb was treated 3 hours later by percutaneous fluoroscopic guided needle injection of 2×10^{11} Ad-hBMP-6 particles in 200ul volume directly into the osteotomy and into the triceps muscle. Rabbits were weekly radiographed. At 8 weeks, rabbits received an intraosseous injection of 2×10^{11} Ad-BMP-6 particles in 200ul volume (one limb) or saline (contralateral limb) into the trabecular bone of the distal femur. Femurs and forearms were radiographed

ADENOVIRAL-MEDIATED TRANSFER OF hBMP-6 GENE ACCELERATES OSTEOTOMY REPAIR CONTINUED....

weekly for an additional 4 weeks prior to euthanasia and histology. Bone did not form in the triceps of any rabbit. Bone resorption was not evident in the trabecular bone of the injected femurs. Greater fracture callus was evident on radiograph within 2 weeks in the hBMP-6 injected ulnae. Mineralized tissue was evident proximal to the elbow of the treated limb suggesting migration of Ad-hBMP-6. These data were used to select a 6 and 8 week endpoint in subsequent experiments to anticipate bony bridging of the osteotomy and to delay injections to assist with local containment of Ad-hBMP-6. An additional 2 rabbits received tricep and lumbar muscle injections of Ad-hBMP-6 and Ad-GFP 13, 7 and 3 days before muscle harvest for RT-PCR. Muscle cell expression of adori plasmid (Ad GFP) and hBMP-6 (Ad-BMP-6) persisted for 13 days at 1-2 fold over rabbit GAPDH expression and was undetectable in uninjected muscle. *Main Experiment* – Eighteen adult white NewZealand rabbits had bilateral ulna osteotomy performed under general anesthesia (Day 0). Ad-hBMP-6 (n=12) and Ad-GFP (n=6) was injected on Day 7 in one limb as in previous studies. Rabbits were weekly radiographed and euthanized at 6 (n=6 Ad-BMP-6 and n=6 Ad-GFP) or 8 (n=6Ad-BMP-6) weeks. After euthanasia, excised forelimbs were scanned using peripheral qCT to determine area, density and mineral content of mineralized callus at and 2 mm proximal and distal to the osteotomy. Thawed forearms were stripped of soft tissue, the ends embedded in PMMA, and the radius resected and pried away from the ulna. The ulnae were tested quasi-statically to failure in torsion (1.5 deg/sec) using a servohydraulic materials testing system. The torque-rotation data were used to compute maximum torque to failure, torsional stiffness, and energy absorbed to failure. After mechanical testing ulnae were embedded undecalcified in PMMA, sectioned (5um), stained with Goldner's Trichrome, and evaluated for callus composition, maturity, cortical continuity, and osteotomy bridging. *Statistical Analysis* – A 2-factor ANOVA was performed to compare among groups and between limbs (injected and uninjected osteotomy controls) followed by the LSD post-test ($p < 0.05$ considered significant).

Results:

Adenoviral injection produced mild inflammation of the forearm for 1 week, but all incisions healed without complication. Radiographic evidence of greater bone formation and earlier progression of osteotomy healing occurred in the treated limb of every animal injected with Ad-hBMP-6 within 2 weeks. Mineralized callus surrounded the osteotomy and was contained to the periosteal surface and soft tissues of the ulna and radius. QCT confirmed greater bone area ($p < 0.0005$) and bone mineral content ($p < 0.0001$) at the osteotomy at 6 weeks in Ad-BMP-6 treated limbs. Ad-BMP-6 treated ulnae were stronger ($p < 0.001$) and stiffer ($p = 0.004$) in torsion at 6 weeks than control ulnae. Ad-BMP-6 treated ulnae were stronger and stiffer ($p = 0.003$) than Ad-GFP treated ulnae.)

Discussion and Conclusion:

These experiments confirm that BMP-6 can be potently osteoinductive in vivo resulting in a structural and functional acceleration of bone repair. Local gene delivery of BMP-6 resulted in at least 2 weeks of BMP-6 expression of transgene in vivo, a biologic response within 2 weeks, and return to biomechanical properties of normal intact ulna within 6 weeks. Relative potency to BMP-2 and the cell type(s) contributing to the accelerated repair cannot be concluded from this study.



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A NEW REDUCTION TECHNIQUE FOR SEVERELY DISPLACED PEDIATRIC RADIAL NECK FRACTURES

Authors: Chris G. Neher M.D. and Martin A. Torch M.D.
Presenter: Chris Neher, M.D.

Introduction:

Severely displaced pediatric radial neck fractures often require open or percutaneous reduction. We propose a maneuver to assist in the closed reduction of these fractures.

Methods:

We prospectively identified four consecutive patients with radial neck fractures caused by valgus force that had failed closed reduction under sedation in the emergency department. All fractures were angulated more than sixty degrees. The patients were placed under a general anesthetic and paralyzed. We performed a reduction maneuver consisting of the following steps. 1. Fluoroscopically localize the radial head and determine the position of the forearm in which the maximum angular displacement occurs. 2. With the arm in extension and in the rotation determined above, the assistant should place a laterally directed force on the proximal aspect of the radial shaft with their thumbs. 3. The surgeon should then place a varus stress on the elbow with one hand and put pressure directly over the radial head with the other.

Results:

We reduced all four fractures to near anatomic. Fractures were followed to union. All but one regained full range of motion, the exception having a five-degree flexion contracture. All patients were pain free.

Discussion and Conclusion:

Open reduction of radial neck fractures is associated with complications not usually seen with closed reduction such as infection, avascular necrosis, and heterotopic ossification. We feel that the described maneuver is a valuable tool in the treatment of these fractures. We recommend considering angulation of greater than sixty degrees to be an indication for reduction under general anesthesia.



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COMPARISON OF MODE OF FAILURE AND FAILURE STRENGTH OF ARTHROSCOPIC SUTURE ANCHORS

Authors: Ross S. Paskoff, M.D., Alan S. Litsky, M.D., Sc.D.,
Grant L. Jones, M.D.
Presenter: Ross Paskoff, M.D.

Arthroscopic labral fixation has become a popular method for stabilization of shoulder instability. SLAP tears and Bankart lesions can be addressed in this manner. Many surgeons are performing these procedures arthroscopically instead of using traditional open methods. Arthroscopic fixation methods include the use of transglenoid bone tunnels, traditional suture anchors requiring knot tying and knotless suture anchors. A number of commercially available devices are available for this purpose. We have evaluated the mode of failure and failure strength of several devices. The Arthrex Bio-FASTak absorbable and FASTak metallic screw-in anchor, the Mitek bioknotless absorbable and metallic knotless suture anchor, and the Arthrotek Harpoon metallic and Lactosorb bioabsorbable screw-in anchor were tested for strength at failure and mode of failure. The Arthrex devices were tested with suture and Arthrex #2 FiberWire. The Mitek GII anchor was used as a control.

The Arthrex FASTak metallic corkscrew anchor with FiberWire demonstrated the highest median strength at failure (308.60N). This was followed by the Arthrex FASTak metallic corkscrew with #2 braided suture (194.5N), the Arthrex Bio-FASTak with FiberWire (156.1N) and with #2 braided suture (153.1N), the Arthrotek Lactosorb (148.1N), the Mitek GII (105.7N), the Mitek knotless suture anchor (100.2N), the Arthrotek Harpoon (85.1N) and the Mitek bioknotless suture anchor (63.0N). The nonparametric Nemenyi median test was used to compare all variables. This test showed the FASTak with FiberWire (median strength 308.6N, $p < 0.01$) and FASTak with suture (194.5N, $p < 0.03$) to be significantly stronger at failure than the GII (105.7N). The bioknotless anchor showed a strong trend toward being weaker at failure than the GII (63.0N, $p < 0.07$). The other devices did not statistically differ from each other. Mode of failure was anchor pullout for the Arthrotek Harpoon, the Mitek GII, and the Mitek bioknotless anchor. The Mitek knotless suture anchor and the Arthrex FASTak with FiberWire failed by pullout and suture breakage. The Arthrex FASTak with #2 braided suture failed when the suture broke and the two Arthrex absorbable anchors failed by breakage of the anchor eyelet. The Arthrotek Lactosorb anchor demonstrated suture breakage, anchor pullout and anchor failure.



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COMPARISON OF SUTURE ANCHORS IN DENSE POLYURETHANE FOAM

Authors: John A. Brem, DPM and Alan S. Litsky, M.D., Sc.D.
Presenter: John Brem, DPM

The objective of this study was to compare the failure strengths of three commercially available suture anchors in a media selected to simulate the structure and mechanical properties of cancellous bone. The three anchor systems chosen were constructed of three different materials and had three different mechanisms of maintaining fixation. The Mitek GII 2.4 is a titanium anchor with two probes which deploy into the cancellous bone upon insertion. The AlloAnchor RC 3.0 is a press fit anchor made of bovine cortical bone and is therefore slowly bioabsorbable. The Panalok 3.5 is a triangular anchor with an asymmetric suture location designed to achieve fixation by angulating within the drill hole. It is also a bioabsorbable anchor, made of polylactic acid.

Thirteen (13) of each anchor were threaded with 24-gauge stainless steel suture to avoid suture failure and thus measure the strength of the anchor-‘bone’ interface. The test media [rigid polyurethane foam, 20 pounds/foot³, Pacific Research Labs, Vashon WA] was chosen for its consistent, homogeneous material properties similar to cancellous bone. All anchors were inserted perpendicular to the substrate surface into predrilled holes.

An 858 Bionix materials testing system [MTS Systems, Eden Prairie, MN] was used to extract the anchors at 0.5 mm/sec with load and displacement continuously recorded. Peak load to failure was measured. Resultant values were compared among the anchor systems using an analysis of variance. The Mitek GII and the AlloAnchor had statistically indistinguishable pull-out strengths, 101 ± 11 N and 109 ± 5 N, respectively. The pull-out strength of the Panalok anchor, 71 ± 40 , was significantly lower ($p < 0.02$) than the other two anchors and had a much higher dispersion. The standard deviation of the Panalok pull-out values was 76% of the mean value, compared to 11% and 4% for the Mitek GII and AlloAnchor systems.

The low pull-out values of the Panalok anchors and the inconsistency of the results (range 2 – 131 N) are worrisome. The dense polyurethane foam used may have inhibited angulation of the Panalok anchor more so than would occur in cancellous bone and corroboration of the results in a cancellous bone material is suggested. The Mitek GII (range 81 – 125 N) and AlloAnchor (range 100 – 115 N) data was much more consistent. Both of these anchor systems provided solid fixation in the test substrate.



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TREATMENT OF SUBTROCHANTERIC FEMUR FRACTURES USING A SUBMUSCULAR FIXED LOW-ANGLE PLATE

Authors: Chris G. Neher M.D. and Robert Ostrum M.D.
Presenter: Chris Neher, M.D.

Introduction:

Subtrochanteric femur fractures without an intact piriformis fossa usually undergo plate osteosynthesis. Subtrochanteric fractures with an intact piriformis fossa but a detached lesser trochanter may be repaired with an extramedullary device or a cephalomedullary nail. We utilize fixed low angle plates (FLAPs) with submuscular plating techniques for the above fracture patterns. This study evaluates our experience.

Methods:

Twenty consecutive patients that had a FLAP implanted for a proximal femur fracture were identified. Indirect reduction, and submuscular plating without bone grafting was performed. A chart review was conducted.

Results:

Average values were: patient age= 36 years, operative time= 111 minutes, EBL= 428cc, varus= 1 degree and time to clinical union= 107 days. Four of the fractures united in $>5^{\circ}$ of varus. No implants failed and all fractures united without secondary procedures.

Discussion and Conclusion:

The shortcoming of cephalomedullary nails is their rate of varus malunion, which has been shown to be as high as 61%. Our rate of 21% compares well. Our average EBL is comparable to that described for cephalomedullary nailing but less than that for similar FLAP devices. Our average operative time of 111 minutes is substantially less than that previously described for implantation of FLAPs. We attribute our lack of implant failure, 100% primary union rate, decrease in EBL and decrease in operative time to our usage of submuscular plating techniques. We recommend submuscular placement of a FLAP device for subtrochanteric femur fractures in which either the piriformis fossa or lesser trochanter is not intact.



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IPSILATERAL SLIDING HIP SCREW AND RETROGRADE INTRAMEDULLARY NAIL: A BIOMECHANICAL COMPARISON OF CONSTRUCTS

Authors: Timothy Reish, M.D., Joseph Mileti, M.D., Brian Davison, M.D., Alan Litsky, M.D., Sc.D., Adam Schaaf, B.A.
Presenter: Tim Reish, M.D.

Introduction: Ipsilateral femoral neck and shaft fractures are frequently stabilized with a sliding hip screw and a retrograde intramedullary femoral nail. Whenever two implants are used in close proximity, an area of stress concentration can be created between the implants. The purpose of this study is to analyze the stress concentration created in a femur instrumented with four five variations of a sliding hip screw, side plate, and a retrograde intramedullary nail. Our goal is to determine the optimal fixation construct to decrease the risk of fracture at this site of stress concentration.

Methods: Third generation composite femora (Pacific Labs, Seattle, Washington) were instrumented with a combination of an Omega sliding hip screw (Howmedica, Rutherford, NJ) and an Alta retrograde intramedullary femoral nail (Howmedica, Rutherford, NJ). Each femoral nail was statically locked with two proximal and two distal locking screws. Five different constructs were used with 4 trials in each construct tested. Group A was instrumented with a 2 hole 130 degree sliding hip screw side plate and a 38 cm retrograde nail that extended to the end of the plate. The remainder of the groups consisted of a 4 hole 130 degree side plate and 38 cm retrograde nail. This resulted in an overlap of the nail with the distal two screw holes of the plate. These holes were not filled in Group B. In group C, the overlapping distal two screw holes were filled with unicortical screws. Group D consisted of bicortical screws placed in the overlapping distal two screw holes. In the last construct, Group E, cerclage wire was placed at the area of overlap between the nail and distal screw holes. An uninstrumented control femur group was also tested.

Each construct was tested on a Bionix 858 servohydraulic materials testing machine (MTS Systems, Eden Prairie, MN) in axial loading (50 N/sec) and in torsion (1.12 N-m/sec) with continuous recording of load and displacement until failure of the construct. The ultimate strength, modulus, peak torque, and torsional stiffness were determined from the load-displacement curves.

Results: In Group A, the ultimate strength to failure in axial loading averaged 3105 N (range 2930-3310). Group B averaged 3403 N (range 3270-3500). In groups C, D and E, the ultimate strength averaged 5207 N, 5402 N and 5023 N, respectively. Strength in the control group averaged 5340 N. There was no statistically significant difference between groups A and B ($p > 0.1$) nor among groups C, D, E and control ($p > 0.8$). However, between group B and group E, there was a statistically significant difference ($p < 0.001$).

With regards to stiffness, groups A through E averaged 929 N/mm, 970 N/mm, 930

IPSILATERAL SLIDING HIP SCREW AND RETROGRADE INTRAMEDULLARY NAIL: A BIOMECHANICAL COMPARISON OF CONSTRUCTS CONTINUED....

N/mm, 882 N/mm, and 969 N/mm, respectively. Control stiffness averaged 905 N/mm. There was no statistically significant difference among the groups ($p>0.65$).

In the torsional arm of the study, the peak torque in group A, averaged 130.3 N-m. Groups B, C, D, and E averaged 132.5 N-m, 137.5 N-m, 134.8 N-m, and 149.7 N-m respectively. Peak torque in the control group averaged 141 N-m. There was no statistically significant difference among any group ($p>0.62$).

Torsional stiffness in groups A through E averaged 9.3 N-m/mm, 7.8 N-m/mm, 8.1 N-m/mm, 8.3 N-m/mm, and 8.0 N-m/mm respectively. The control group averaged 10.7 N-m/mm. Again there was no statistically significant difference among any of the constructs ($p>0.88$).

Conclusions: A combination of a sliding hip screw and a retrograde intramedullary femoral nail is an option in certain clinical scenarios for treatment of femur shaft fractures associated with femoral neck or intertrochanteric fractures. In this biomechanical study, we found that the ultimate strength in axial loading was significantly higher in constructs consisting of unicortical screws, bicortical screws or cerclage wire filling the overlapping holes in the sliding hip screw side plate. We did not find any difference between those constructs with unicortical versus bicortical screws or cerclage wiring in the overlapping region of the side plate. There was no statistical significance between any of the constructs tested in torsion.

Clinical Relevance: With use of an ipsilateral sliding hip screw and retrograde intramedullary femoral nail, a potential stress concentration is formed between the two implants. There is no published study identifying the most biomechanically sound construct to minimize this stress concentration. Decisions with regards to this fixation are made empirically by the surgeon. This study provides biomechanical evidence that overlap of the side plate and nail with unicortical screws in the overlapping region provides for a construct with the highest ultimate strength in axial load and minimizes the risk of a subsequent fracture at this area of stress concentration. In addition, placing bicortical screws or cerclage wires at the implant overlap provides no additional strength to the construct and is unnecessary in young healthy bone.



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THE ANATOMY AND ISOMETRY OF THE MEDIAL PATELLOFEMORAL LIGAMENT: IMPLICATIONS FOR RECONSTRUCTION

Authors: William McDonald, M.D., Robert Steensen, M.D., Ryan Dopirak, M.D.

Presenter: William McDonald, M.D.

Dissection of the medial patellofemoral ligament (MPFL) was conducted in eleven fresh frozen cadaveric knees (seven cadavers). The anatomy of the MPFL was described and its relationship to the medial epicondyle, vastus medialis oblique, medial collateral ligament, and patella was recorded.

Isometry was evaluated by making three points on the medial side of the patella (A, B, C) and the medial epicondyle (D, E, F). These points correspond to the most superior edge, the midpoint, and the inferior edge of the ligament. The measurements were obtained at various fixed angles of knee flexion (0, 30, 60, 90 and 120 degrees). All measurements were obtained with a 152mm dial caliper (General Tools, New York, New York). The data collected was graphed and analyzed to assess for the most isometric point, if any, of the MPFL.

This article describes the isometric characteristics of the MPFL. The information presented in this article may prove to be beneficial in the future of reconstructive procedures of the medial side of the knee.

BUECHEL PAPPAS™ TOTAL ANKLE REPLACEMENT SYSTEM STUDY: A SHORT-TERM DATA ANALYSIS

Authors: Tina S. Demou, DPM, Leonard Janis, DPM, Alan Block, DPM

Presenter: Tina Demou, DPM

This retrospective study evaluating short-term data results of the Buechel Pappas Total Ankle Arthroplasty. Twenty total ankle arthroplasties were performed by a single surgeon over a one year period. Indications for this ankle arthroplasty included a primary diagnosis of osteoarthritis, post traumatic arthritis or rheumatoid arthritis.

After a three month, six month, and one year post operative period, the patients were asked to evaluate their progress based on the New Jersey Orthopedic Hospital Ankle Evaluation Form. This rating system incorporates both subjective and objective factors into numerical scales to describe pain, function, range of motion, deformity, and patient satisfaction. Overall a significant improvement in the above criteria was seen post-operatively. There was an average of 63% improvement in reduction of pain, 35% improvement in function, and 27% improvement in range of motion of the new ankle joint.



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MICROMOTION MEASUREMENT IN ARTICULATING HIP PROSTHESES: AN *IN VITRO* ANALYSIS

Authors: Eric J. Prenger, Alan S. Litsky, M.D., Sc.D.
Presenter: Eric Prenger

Polyethylene wear debris is the dominant factor in the late-term loosening of total hip arthroplasties and the leading problem necessitating revision surgery. Particles generated from the joint side of the implant account for a substantial portion of the debris, but backside wear (occurring at the articulation between the metal cup and the PE liner) also contributes to the problem. Backside wear has been correlated with the amount of micromotion at this interface. Research in the Orthopaedic BioMaterials Laboratory has developed an accurate technique for measuring motion at this interface under quasi-static conditions. Currently there are no studies that attempt to quantify the amount of backside wear in articulating hip prostheses. The goals of this project were to develop a technique for measuring micromotion under articulating conditions and to gather data testing the hypothesis that micromotion under “articulating” conditions is significantly different than previous data gathered under quasi-static conditions.

Custom fixtures were designed to mount the acetabular cup and femoral component of the implant to an MTS biaxial servohydraulic material test frame. A load cell was coupled inline with the femoral component and recorded the load applied to the liner during testing. The micromotion of the liner relative to the cup was gathered by a series of Linear Voltage Differential Transformers (LVDTs) mounted securely to the cup. To load the cup, the material test fixture applied an axial load and a rotational displacement to the femoral component. As the axial and rotatory loads are cycled, a resultant force of 2000 N is applied over a 60° arc in the liner. Both the torque and axial load can be varied. Data was gathered for 10 consecutive loaded articulating cycles at certain intervals: 100 cycles, 1000 cycles, 10,000 cycles and then at 10,000 cycle intervals up to 200,000 cycles.

The initial testing protocol included four *Pinnacle* implants supplied by DePuy, Inc., [Warsaw, IN]. The testing showed that the micromotion data for the *Pinnacle* design obtained during articulation is significantly different than the micromotion data obtained during quasi-static axial loading. It is believed that the difference in data results from the inclusion of the complex forces the implant experiences while under simulated articulating motion.

The next steps of this project are to share the initial results with the leading hip implant manufacturers. Then we can continue to test additional implant designs, both current production or prototype designs, to further test our hypothesis.



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LASER SHOCK PEENING INCREASES FATIGUE LIFE OF CORTICAL BONE SCREWS

Authors: Chris B. O'Sullivan, DVM; Alicia L. Bertone, DVM, Ph.D.;
Alan S. Litsky, M.D., Sc.D., James T. Robertson, DVM
Presenter: Chris O'Sullivan, DVM

Laser shock peening (LSP) is a process that imparts a compressive residual stress into the surface of a metal improving strength, hardness and offering potential improvement in fatigue life. The technique utilizes a surface laser induced explosion to produce a shock wave that causes a rapid tensile yielding that imparts a permanent surface compressive residual stress. LSP has been most widely implemented in the aerospace industry to prolong fatigue life of jet turbine blades but has not previously been applied within the biomedical field.

The purpose of this study was to investigate the potential application of the laser shock peening process on orthopaedic hardware to enhance fatigue life. To investigate this we stated a hypothesis; "Laser shock peening of 3.5mm stainless steel cortical bone screws at the mid-shaft will enhance fatigue life when subjected to three point bending." The selection of 3.5mm cortical screws was based on its frequent application in veterinary surgery and reduced costs of application of LSP compared to other cortical screws. Our objective was to apply increasing doses of laser energy to the midshaft of screws and determine the effect of LSP on fatigue life when subjected to three-point bending. Scanning Electron Microscopy (SEM) was utilized to observe any alterations in screws surface characteristic and examination of the fatigue fractured screw ends after complete failure was induced was undertaken to determine the mode of failure.

Thirty-two 3.5 mm diameter, 40 mm long stainless steel cortical bone screws were divided into 4 groups (n=8/group). Group 1 was the untreated control. Groups 2, 3 and 4 screws were treated at their midshaft with 4 pulses of commercial LSP (LaserPeen™) applied at their midshaft, 18-24 mm from the screw tip. An increasing fluence was applied to each group. Group 2 received a density of 6 GW/cm² and duration 8 ns, group 3 received density 6 GW/cm² and duration 12-14 ns, and Group 4 received a density of 8.5 GW/cm² and duration of 20 ns. All screws were cyclically loaded in three-point bending in a servohydraulic materials testing machine [Bionix 858, MTS Systems, Eden Prairie, MN]. The cyclic loading protocol consisted of a looped pattern of 9900 cycles between 20 and 250 Newtons at 35 Hz, 90 cycles of between 20 and 250 N at 1 Hz, and 10 cycles between 20 to 750 N at 1 Hz. This loading triad was repeated until the screw deformed beyond the failure displacement of 3mm; the number of cycles to failure was recorded. SEM was utilized to examine the treated and untreated areas of both LSP and control screws.

LASER SHOCK PEENING INCREASES FATIGUE LIFE OF CORTICAL BONE SCREWS CONTINUED

A significant 11% improvement ($p=0.006$) in the mean number of cycles to failure was seen in screws treated with power density of 6 GW/cm^2 group 2 (60,448 cycles), and group 3 (62,852 cycles) screws compared with control group 1 (55,491 cycles) screws. A 20% decrease ($p=0.01$) in mean fatigue life was seen in group 4 screws (43,907 cycles) compared with control group 1. SEM examination revealed surface roughening in the treated midshaft area of all treatment groups that increased with energy density. The fractured ends of the screws showed evidence of cyclic fatigue as fatigue bands (striations) could be seen radiating longitudinally from the site of crack initiation. The decreased fatigue life of the group 4 screws is likely due to damage to the surface and grain structure as indicated by the surface roughening and longitudinal cracking of these screws as seen on SEM. Such surface defects may act as stress risers and crack initiators, subsequently decreasing fatigue life.

This study indicates that laser shock peening may hold potential for improving fatigue life when applied to cortical bone screws. A modest improvement in fatigue life (11%) was achieved in 6 GW/cm^2 screw groups, the investigation of additional energy densities and pulse durations is warranted.



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INTRA-ARTICULAR FINDINGS IN THE MULTILIGAMENT INJURED KNEE

Authors: Christopher Kaeding, M.D., Kurt Spindler, M.D.,
Richard Parker, M.D.

Presenter: Christopher Kaeding, M.D.

Objective

To determine the pattern of meniscal and articular cartilage damage in subjects who sustained an injury to more than one knee ligament. An analysis was performed on prospectively collected data using the Multi-center Orthopaedic Outcomes Network (MOON) and first author's databases on subjects who underwent surgery due to multiligamentous injuries.

Methods

Physicians affiliated with the MOON group evaluated and documented intra-articular findings at the time of surgery which were subsequently placed in the database. Subjects were placed in groups determined by their combination of ligamentous injuries (ex: ACL/PCL, ACL/PCL/MCL). Findings documented for each group included; partial or complete meniscal tear as well as presence and location of significant chondral injury. Criteria for significant chondral defect was; any grade 2 involving 50% or more of condylar width, all grade 3, or all grade 4 lesions. Chondral injury was graded in severity on a 1-4 scale with 1=softening, 2=fissures/superficial damage, 3=fragmentation/deep partial thickness damage, and 4=exposed bone. Occurrence and pattern of meniscal and chondral injury were identified for each group and compared to the isolated ACL injury group. Groups with more than 10 subjects were compared against the ACL only group. Groups with less than 10 subjects were considered rare and presented in table form only.

Results

Data was collected on 2208 subjects. A total of 13 groups were identified. All groups were mutually exclusive. The groups were: ACL only (2028), ACL/MCL (73), ACL/LCL (46), ACL/PCL (19), ACL/MCL/LCL (12), PCL only (10), ACL/PCL/MCL (8), PCL/MCL (3), ACL/PCL/LCL (3), MCL only (2), PCL/LCL (2), LCL only (1), and ACL/PCL/MCL/LCL (1). A total of 40% of all multiligamentous injuries were in the ACL/MCL group. The ACL/LCL group accounted for another 25%. Together, these two groups represented 2/3 of all multiligament injuries. The ACL/MCL and ACL/LCL groups were significantly different from the ACL only group in their rates of medial meniscal damage ($P < 0.001$ and $P < 0.05$ respectively). The ACL/LCL group was also significantly different from the ACL only group in its rate of lateral meniscus damage ($P < 0.05$). The ACL/LCL group had significantly higher rates of lateral femoral condylar as well as patellar damage than the ACL only group ($P < 0.05$). The ACL/MCL group had significantly lower rates of medial femoral condylar damage than the ACL only group ($P < 0.05$).

INTRA-ARTICULAR FINDINGS IN THE MULTILIGAMENT INJURED KNEE CONTINUED....

Conclusions

Patients who undergo knee surgery for a ligament injury are most likely to have injured only their ACL. ACL/MCL, ACL/LCL, ACL/PCL, and ACL/MCL/LCL are the most common multiligament injury combinations. All other groups are more rare multiligament injury combinations. Those patients who injure more than one knee ligament follow unique patterns of intra-articular damage. The meniscal and chondral injury patterns were different for different ligament injury combinations. Further study of these intra-articular injury patterns will assist surgeons in better understanding the prognosis and treatment implications of specific multiligament injury combinations.

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