The Taylor Collaboration

The Taylor Collaboration is a consortium of professional educators, clinicians, and researchers.

The core of The Taylor Collaboration is its biomechanics laboratory, located at St. Mary’s Medical Center Campus in San Francisco, California.

We are a not-for-profit organization administered by a board that includes engineers, clinicians, and members of the general public with expertise in healthcare administration.

The focus of The Taylor Collaboration is principally in Orthopaedics, but we also support biomechanics-focused projects in pediatric surgery, podiatry, general surgery, and neurological surgery.

The laboratory specializes in mechanical testing of medical devices, with a particular emphasis on orthopaedic implants.

Our History

The Taylor Collaboration is named in honor of Dr. Lloyd W. Taylor, a distinguished orthopaedic surgeon and educator.

Taylor served as an Army officer and the head of the Orthopaedic Surgeon's Department at Letterman Army Hospital in San Francisco. After Taylor’s Army retirement in 1962, he became the Chief Orthopaedic Surgeon and trained thousands of residents at St. Mary’s Hospital.

Dr. Lloyd W. Taylor was also president of Western Orthopaedic Association, The American Academy of Orthopaedic Surgeons, Treasurer of the American Orthopaedic Surgeons, and the John Wilson Interurban Association.

Our Mission

Our mission is to enable the world's best surgeons and engineers to solve orthopaedics' most ambitious problems through:

Research
We investigate, understand, and explain meaningful orthopaedic procedures and devices

Education
We train the next generation of surgeons and engineers

Innovation
We build promising techniques and technology

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Clinical Relevance
In orthopaedic trauma surgery, locking plates and screws have revolutionized the fixation of osteoporotic fractures. This study aimed to evaluate the combination of the traumatology principle of fixed-angle locking plate fixation with the spine principles of segmental instrumentation.

Methods
Spinolaminar locking plate designed to fit vertebrae thoracolumbar morphology. Plates were fixed to cadaveric human lumbar spines and connected to form 1-level L1-L2 & L4-L5 constructs and compared to similar pedicle screw constructs. Pure moment, fatigue testing, load to failure, and post-fatigue fixture pullout tests were conducted

Results
Spinolaminar plate fixation resulted in 240% and 30% greater pullout energy and strength compared to pedicle screws. Moreover, plates were superior to pedicle screw fixation with respect to cyclic fatiguing and pullout strength.

Conclusion
Spinolaminar locking plate maintained adequate fixation post-fatigue, particularly in flexion/extension and axial rotation compared to pedicle screws. Moreover, plates were superior to pedicle screw fixation with respect to cyclic fatiguing and pullout strength.

Figure: Axial 3D reconstructions of the spinolaminar plate depicting: A, the anatomic placement in the lumbar spine & B, spinolaminar plate without screws and C, the combination of locking screws and a polyaxial head and set screw.

Figure: Fracture Description, and test set up

Figure: Digitized fracture and fixation construct

Clinical Relevance
Fracture reduction of infractural T-type acetabular fractures (62B2.1) affects the contact mechanics and stability of the hip joint. This study aimed to determine the threshold of displacement that would affect contact pressures to a point at which improvement of reduction may have a benefit compared to allowing the fracture to heal in the malreduced position.

Methods
Two paired fresh-frozen human cadaveric hips tested under 70 kg compressive load through acetabulum in single leg stance position. Thin-film sensors measured contact area, pressure, and peak force. Testing performed with native acetabulum then acetabulum induced with 62B2.1 fractured with 2mm step-off and widening of 0 mm, 1mm, 2mm, and 5mm. Each testing condition evaluated at 0° and 60° flexion (F), while at 0° and 10° adduction (A) to simulate gait postures.

Results
The contact area decreased from the intact acetabulum with increased widening by 51±3%, across all positions, except 60°F-0°A. Contact pressures were highest in the posterior superior portion of the native acetabulum. Trend in contact pressure increased to a maximum of 118±3% across 10°A positions. Contact pressure increased by 16-24% when increasing fracture gaps incrementally from 1mm to 5mm across all positions. Peak force reduced by 15±2% at 1mm gap across all positions. Peak forces increased significantly at 2mm and 5mm gaps across all positions. Peak forces increased by 131±50%, 145±6%, and 115±3%.

Conclusion
A fracture gap beyond 1mm in displaced infractural T-type fractures results in increased contact and peak forces on the acetabulum. T-type fracture fixation should aim to minimize the fracture gap at 1mm.

Figure: Fracture Description, and test set up

Figure: Digitized fracture and fixation construct

Clinical Relevance
Distal femur fractures are difficult to successfully treat due to high rates of nonunion. Obesity is an independent prognostic risk factor for nonunion. This study aimed to determine the impact of body weight on fracture strain in a lateral locking plate constructs for suprcondyilar femur fractures.

Methods
A 3D finite element analysis was performed on two separate digitized cadaveric computed tomography femur models with a comminuted OTA/AO classification 33A distal femur fracture with a lateral distal femoral locking plate using a bridge plate construct with Ansys software. Axial loads of 70 kg & 140 kg to represent normal and obese patient body masses were applied. The screw density & working length were varied, as interfragmentary strains (IFS) & shear motions (SM) at fracture site were compared.

Results
In the standard working length model, IFS increased from 1.91% ± 1.12% to 3.32% ± 1.82% between normal and obese models. Short and intermediate working lengths reduced the IFS of the obese model to 1.06% ± 0.27% and 2.19% ± 1.09% respectively, which were comparable to the normal IFS. A similar trend was found for shear motion. Increasing screw density from 40% fill to 60% fill decreased the IFS in the normal and obese models but did not decrease shear motion.

Conclusion
The present study used a finite element model to demonstrate that increased axial load increases interfragmentary strain in an AO/OTA 33A distal femur fracture fixed with a lateral distal femoral locking plate. Decreasing the working length of fixation constructs in the obese model normalized interfragmentary strain and shear motion.
Missing the First Post-operative Visit is an Independent Risk Factor for 90-day Complication and Re-admission Following Hip Fracture Surgery (in press)

Adam Schluach, Ishan Shah, Maria Caicedo, Oluwatodimu Richard Raji, Brian Farrell

Clinical Relevance
Knowing the risk factors for poor outcomes following hip fracture surgery is necessary for appropriate patient care. This study aimed to determine the influence of the first post-operative visit (POV) following hip fracture surgery on mortality, complications, and re-admissions.

Methods
Retrospective review of 285 patients who underwent operative fixation of a hip fracture. Outcome measurements were 90-day and one year mortality, 90-day complications, and 90-day re-admission rates in patients who missed or attended their first POV following hip fracture surgery.

Results
76.3% made their first POV. 90-day and one-year mortality were higher in the patients who missed their first POV. (ORs = 7.57, 4.06, respectively) Independent risk factors for 90-day complications were missing the first POV, coronary artery disease, and lower pre-injury status (ORs = 10.65, 2.80, 7.89, respectively). Independent risk factors for 90-day re-admission were the first POV, chronic obstructive pulmonary disease on home oxygen, and lower re-injury status (ORs = 8.04, 5.44, 5.47, respectively).

Conclusion
Missing the first POV was the strongest independent risk factor for 90-day complications and 90-day readmission. Patients who miss their first POV have significantly higher 90-day and one year mortality rates.

Are all cages created equal? Analysis of Cervical Cage Malfunctions Using FDA MAUDE Database (in press)

Victor Ungurean, Amit S Piple, Oluwatodimu R Raji, Andrea Rowland, Adam Schlauch, Dimitriy G Kondrashov, Ken Y Shu, James F Zucherman

Clinical Relevance
As interbody cage usage during cervical interbody fusion grows in the United States, there has been a concurrent rise in implant material, manufacturing and design options. This study aimed to characterize failure rates of cervical interbody cages by their manufacturer & production material.

Methods
The FDA’s Manufacturer and User Facility Device Experience (MAUDE) database was queried for all reports of cervical interbody cage device failures from 2012 to 2021. Each report was analyzed and categorized by failure type, core and surface material, which was obtained from 510(k) premarket notifications. Failure to market share indices were generated by dividing the material subtype failures by its yearly U.S. market share. Failure to revenue indices were calculated by normalizing the annula failure to manufacturer spine revenue.

Results
807 entries were identified. 42.6% were cage breakages, 21.4% were instrumentation-related failures, 20.9% were assembly failures, 9.9% were screw failures, and 6.7% were cage migrations. 95.1% of broken cages were composed of a PEEK core. 50% of migrated cages were PEEK surfaces, and 43.8% were Titanium. PEEK implants had a higher failure by market share index for both migration and breakage compared to titanium. Upon manufacturer market analysis, Zimmer-Biomet as of 2021, was found to have failure to revenue indices exceeding the calculated threshold.

Conclusion
A year-over-year reduction in failure to market share indices was observed for both PEEK and titanium. Further studies regarding the influence of patient and operative factors on cervical interbody failures are warranted as the MAUDE database does not contain clinical data.

An Analysis of a Decade of Lumbar Interbody Cage Failures in the United States: A MAUDE Database Study (in press)

Amit S Piple, Victor Ungurean, Oluwatodimu R Raji, Andrea Rowland, Adam Schlauch, Dimitriy G Kondrashov, Ken Y Shu, James F Zucherman

Clinical Relevance
Perioperative lumbar interbody cage malfunctions are underreported and may result in complications. While device safety under physiological conditions post implantation has been documented, devices experience non-physiological conditions during implantation, which may be overlooked.

Methods
Reports of lumbar cage device malfunctions from 2012-2021 in the FDA MAUDE database were analyzed and categorized based on failure type and implant design. The total number of failures per year for each manufacturer were divided by their approximate yearly revenue from spinal implants in the U.S. Outlier analysis was utilized to generate a failure threshold value.

Results
1,875 lumbar cage malfunctions were identified. 65.6% were cage breakages, 13.7% were instrument malfunctions, 9.4% were cage migrations, 7.6% were assembly failures, 4.5% were screw-related failures, and 1.1% were cage collapses. 74.9% of breakages occurred during insertion or impaction and 10.5% of which resulted in a medical complication. 88.6% of migrations were identified postoperatively, and 47.1% detailed related complications and 33.5% required a revision procedure.

Conclusion
Lumbar cages with PEEK core material failed more frequently by breakage, whereas titanium surface cages failed more frequently by migration. These findings call for a more detailed FDA evaluation of these intraoperative malfunctions prior to commercial approval.

Figure: Distribution of all lumbar cage failure subtypes identified through the MAUDE database.
C1-C2 Facet Joint Penetration by C2 Pedicle Screws: Influence of Local Anatomy, Bone Mineral Density, and Screw Length  
**Abstract**  
C1-C2 facet joint penetration may alter normal biomechanics and accelerate degeneration. This study aimed to clarify how local anatomy, surgical technique, and implant characteristics may relate to C2 pedicle screw penetration into the C1-C2 facet joint.  

**Methods**  
C2 pedicle morphometry, facet joint angle, axial and sagittal pedicle screw angles, screw length, and evidence of facet joint penetration (FJP) of C2 pedicle screws were assessed using intraoperative fluoroscopic and postoperative computed tomography (CT) images.  

**Results**  
Sagittal C1-C2 facet joint angle and axial screw angle were significantly lower in the FJP group compared with the non-FJP group. Sagittal screw angle and screw length were significantly higher in the FJP group compared with the non-FJP group.  

**Conclusion**  
Lower sagittal angle of the facet joint, higher sagittal angle of the pedicle screw, and screw length >24 mm are associated with higher risk of C1-C2 FJP. When placing C2 pedicle screws under these conditions, caution should be taken to avoid FJP.

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Pelvic Stability During Simulated Total Hip Arthroplasty Motions: Comparing Different Hip Positioners  
**Abstract**  
Total hip arthroplasty (THA) requires forceful maneuvers that can cause the pelvis to shift from its original position. This study aimed to quantify the pelvic stability under various hip positioners, during surgeon induced motion in the lateral decubitus position.  

**Methods**  
The rotation and translation of the pelvis in whole body cadaver model was optically tracked and quantified through the hip range of motion, while secured in the lateral decubitus position using four commercially available hip positioners: Beanbag, Pegboard, Stulberg, and ExactFit.  

**Results**  
The ExactFit positioner was most stable, and the bean bag was least stable with maximum rotation of 3.2° and 41.5°, respectively. The Stulberg and Pegboard positioners showed intermediate stability, with a maximum rotation of 7.8° and 17.1°, respectively. Hip flexion and internal rotation were most mobile.  

**Conclusion**  
The ExactFit positioner was associated with the smallest amount of pelvic motion during simulated motions of hip arthroplasty. Stability may influence clinical outcomes following total hip arthroplasty.

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Does the Bone Mineral Density of the Lumbar Spine Correlate with DEXA T-Score? A Cadaveric-Based Analysis of CT Densitometry  
**Abstract**  
Osteoporosis is a risk factor for fixation loosening. Dual-energy x-ray absorptiometry cannot detect variations in bone mineral density (BMD). This study aimed to assess the correlation of T-scores with cortical and cancellous BMD of pedicles and other 6 anatomical regions of lumbar spine.  

**Methods**  
Cadaveric L5 vertebrae computed tomography scans were digitally isolated into cortical and cancellous bone, and into anatomical regions using 3-d modeling software. Hounsfield units (HU) were determined and converted to BMD. Correlations between T scores and HU values were calculated.  

**Results**  
Cortical BMD of pedicles was strongly correlated; lamina, inferior articular process (IAP), superior articular process (SAP), spinous process, and vertebral body were moderately correlated; while transverse process was weakly correlated to the T score. Cancellous BMD of vertebral body was strongly correlated; pedicles, spinous process, and transverse process were moderately correlated, while lamina, IAP and Sap were weakly correlated.  

**Conclusion**  
The cortex of the lumbar pedicle, and the cancellous bone of the vertebral body are strongly affected by osteoporosis. Cortical and cancellous BMD of transverse process and lamina are less affected by osteoporosis.
Clinical Relevance
Presenting clinical symptoms of spinal infections are often nonspecific and a delay in diagnosis can lead to adverse patient outcomes. This study aimed to analyze the risk factors for multifocal spinal infections, for which morbidity and mortality vs unifocal spinal infections are significantly higher.

Methods
Single site retrospective review of all pyogenic non-tuberculous spinal infections treated surgically from 2006-2020. Medical records, imaging studies, and laboratory data of 43 patients reviewed and analyzed. Univariate and multivariate analyses performed to identify risk factors.

Results
15 patients (35%) had multifocal infections. In univariate analysis, there was a significant association with chronic kidney disease, gender, white blood cell count, and cervical or thoracic involvement. In multivariate analysis, both cervical and thoracic involvement remained statistically significant.

Conclusion
Patients with infections in the thoracic or cervical region are more likely to have a multifocal infection. Multifocal pyogenic spinal infections remain a significant clinical challenge.
Viability and Accuracy of Regional Volumetric Radiographic Density as tool for predicting Lumbar Pedicle Screw Fixation Strength: A biomechanical Study (Ongoing)

Effects of Lumbar Spine Compression on Surface Topography and Erosion During Interbody Cage Impaction - A biomechanical Study (Ongoing)

Intraoperative Distraction Increases Joint Visibility During Knee and Ankle Arthroscopy: A Cadaveric and Clinical Study (Ongoing)

Knee Joint Laxity and Distraction Tolerance Distribution: Influence of Pre-Intraoperative Knee Distraction Mismatch on Clinical Outcomes

Fibular Shortening and Malrotation during Ankle Fractures Fixation Influences The Contact Mechanics of The Subtalar and Talofibular Joints: A Biomechanical Study

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Variations in Cervical Regional Density Distributions

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Cervical Densitometry: Variations on Level and Differences between Prehistoric and Modern Man

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Comparison of Pedicle vs Locking Plate Fixation in an Osteoporotic Foam Block Model: Influence of Locking Screw Distribution

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