Joint Function Research Successes with Pressure Mapping

Showcasing Applications for Low-Profile Pressure Measurement Technologies in Joint Research

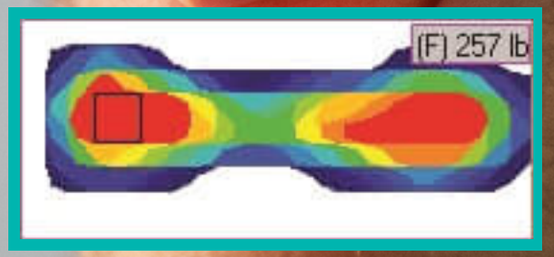

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Table of Contents

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INTRODUCTION

Delivering Quantifiable Clarity Within Impossible Spaces

Today's operating rooms certainly look a lot different from how they used to, even from just a few short years ago. Minimally invasive surgical systems, including robotics, have taken much of the guesswork out of several surgical procedures, leading to improved success rates, and faster recovery. Surgeons – as well as patients – have grown to trust technology to deliver insights and streamline procedures with a high level of precision.

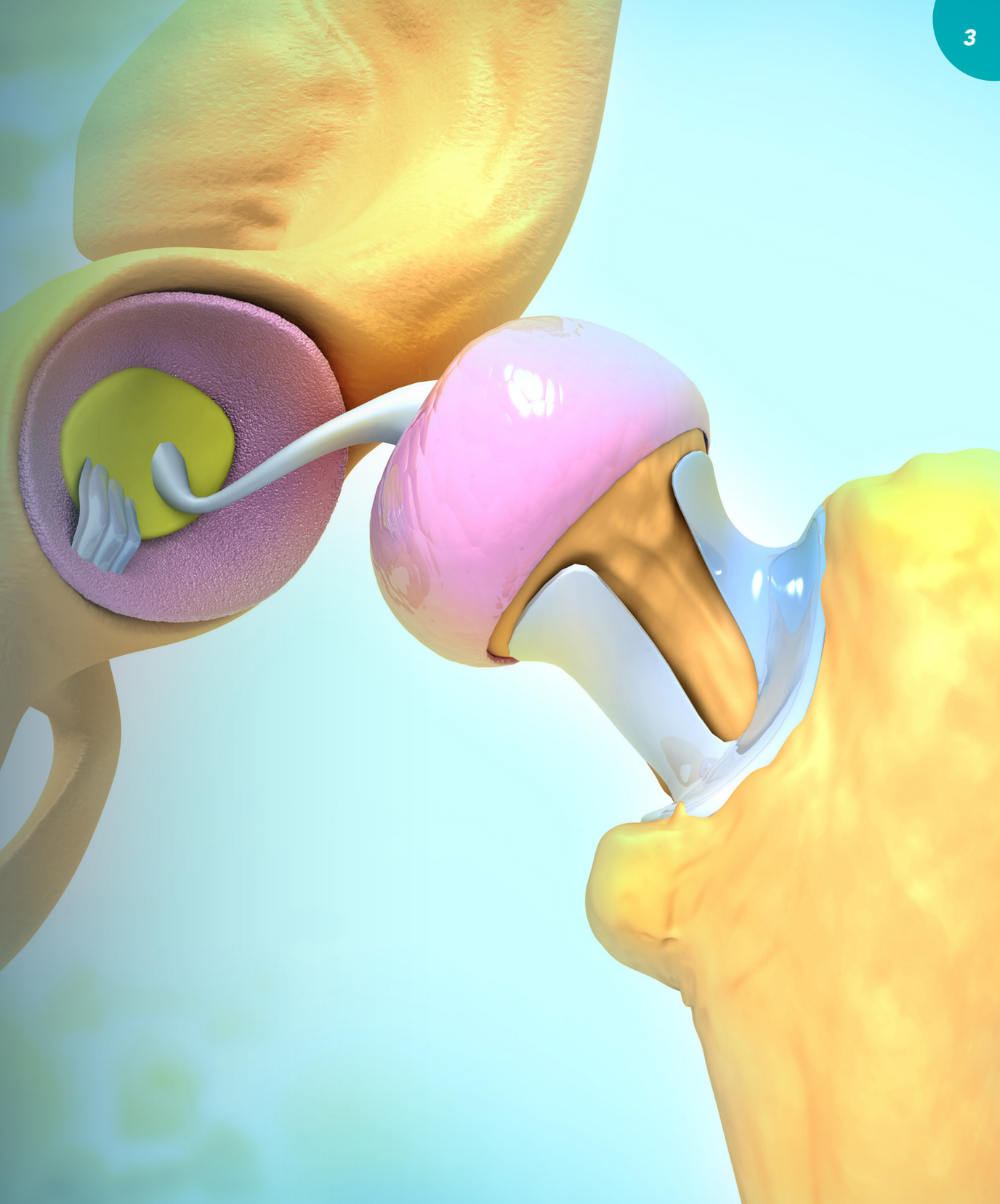
Nevertheless, for orthopedic surgeons, **treating patients with joint pain remains a primarily manual process.** Even with the years of schooling and residencies, there is still a guess-and-check element to these types of procedures, especially since every patient offers their own unique challenges. The slightest misalignment can prompt significant long-term pain for the patient, and possibly lead to additional rehabilitation or follow-up procedures.

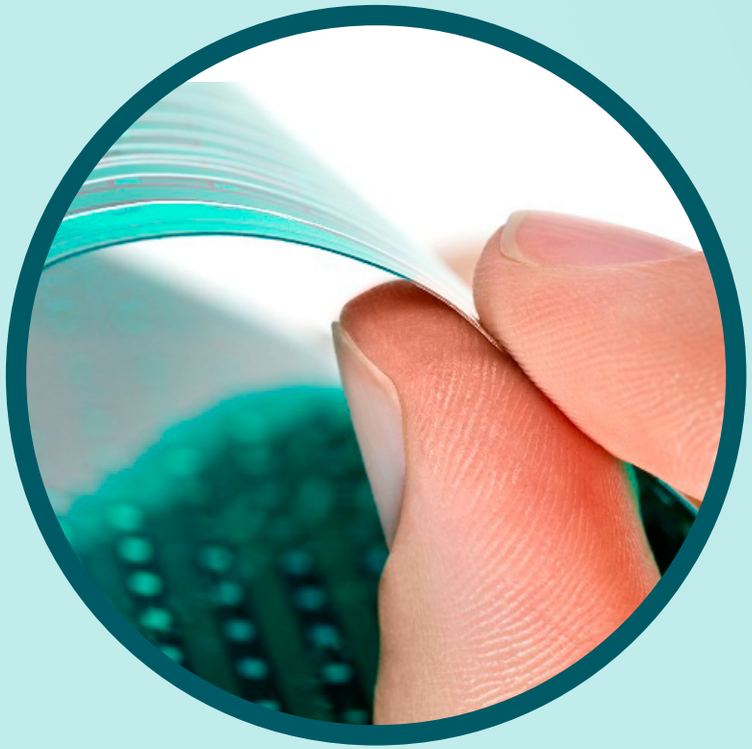
While joint-balancing may never be a perfect science, innovative research technologies help medical researchers capture incredible insights on joint behavior. These findings go a long way in helping improve standards for treating joint challenges of all kinds.

Pressure mapping systems have been shown to be useful tools to capture insights in cadaver studies. Utilizing paper-thin pressure sensors, researchers have the ability to map pressure distribution of joints and assess loading and off-loading on key contact points. Common applications include:

- Determining loading force, pressure, and contact area
- Providing data for dynamic and finite stress analysis
- Study articulating joints
- Viewing and assessing the impact of various joint compartment geometries, and several others

This eBook focuses on research-validated pressure mapping systems for joint behavior research. It will begin with an introduction to the **K-Scan**™, Tekscan's pressure mapping system for joint analysis, and support its validation with real-world research summaries from users.

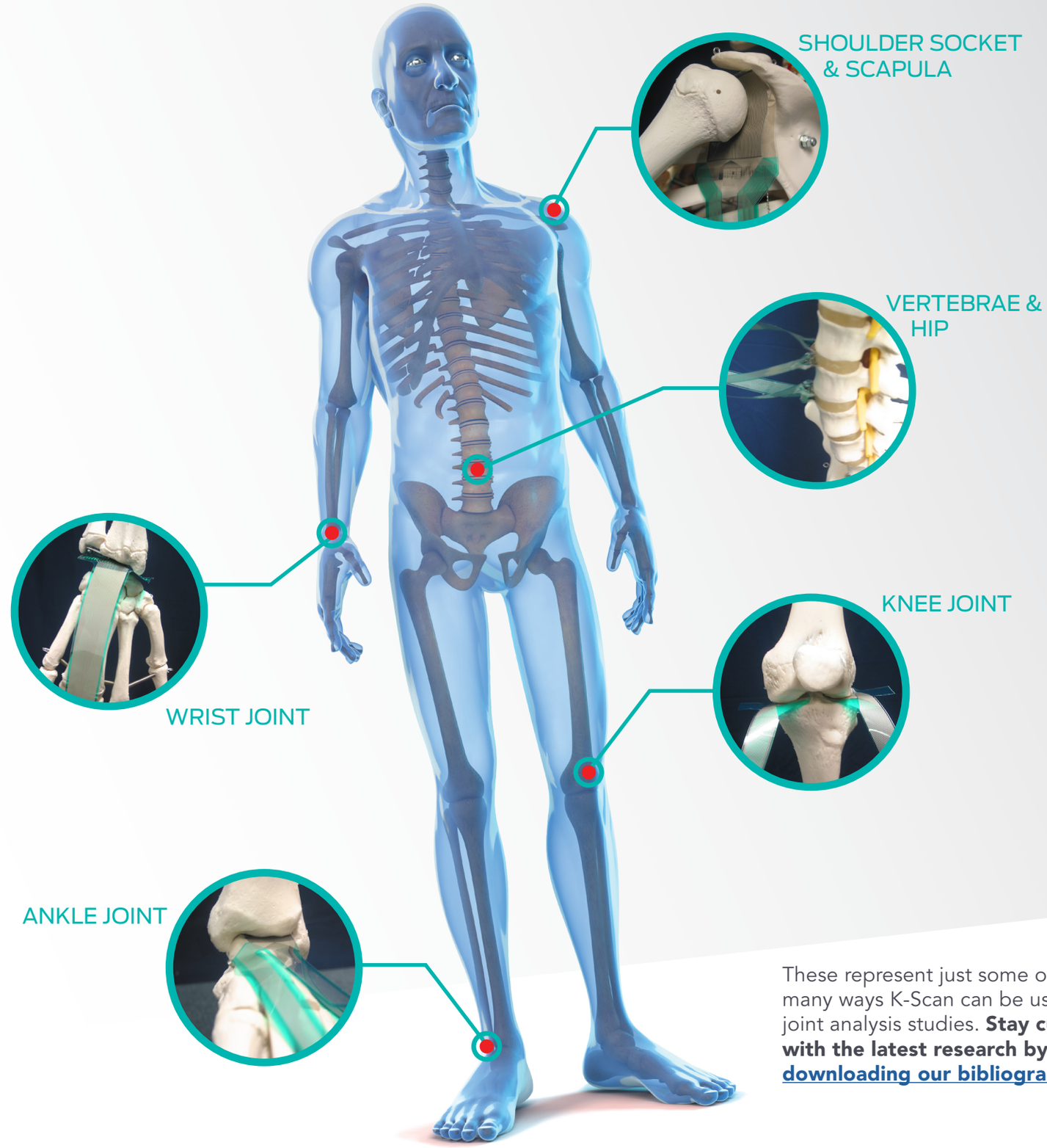




K-Scan™

TEKSCAN'S HEAD-TO-TOE JOINT ANALYSIS SYSTEM

K-Scan is used by researchers to capture objective and quantifiable joint analysis data for both humans and animals. The system measures pressure, force, and contact area between adjacent articulating bones to provide a better understanding of how they are functioning, articulating, and loading.

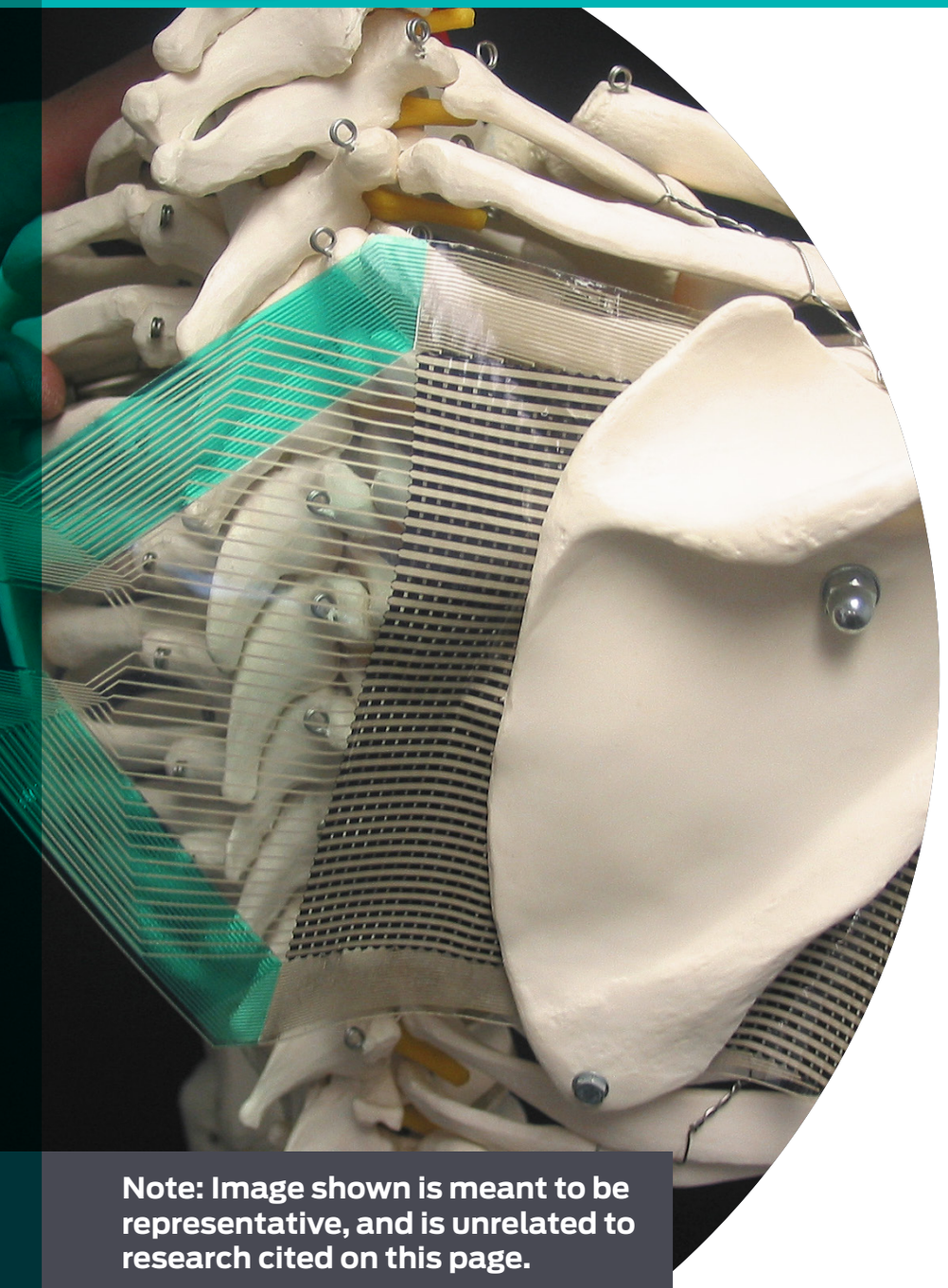


These represent just some of the many ways K-Scan can be used in joint analysis studies. **Stay current with the latest research by downloading our bibliography.**

Joint Analysis Research Successes

Shoulder Joint Research

CITATION: Cheng-Li, L., et al "Different Suture Anchor Fixation Techniques Affect Contact Properties in Humeral Greater Tuberosity Fracture: a Biomechanical Study" (2019) BMC Musculoskeletal Disorders 20:26



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Background:

Suture anchor-based fixations of humeral greater tuberosity (GT) have shown favorable results to promote shoulder healing after surgery. However, there is little biomechanical data regarding the fixation method of GT fractures available. In this cadaveric study, the researchers investigated:

- Contact pressure and contact area at the facture interface of two double-row fixation techniques, both initially after fixation and over time; and
- The contact pressure and contact area that the fracture interface under cyclic loading of the rotator cuff tendon at abduction angles of 0°, 30°, and 60°

Testing Procedure:

- Twelve fresh-frozen cadaveric shoulder specimens (mean age of 60.7 years), without evidence of previous shoulder ailments, were used in the study
- Two types of fixation were performed:
  - Suture-bridge fixation (SB)
  - Double-row suture anchor fixation (DR)
- A **K-Scan pressure mapping system** was used to measure contact pressure and area between GT-fragment interface and its underlying humerus fracture site
  - The system recorded applied pressure directly after repair and for 60 minutes at set time intervals
  - The shoulder specimens were cyclically loaded until 100 N, and tested at 0°, 30°, and 60° of abduction

Results:

- Both the SB and DR configurations showed decrease contact pressure and area over time
- The SB group showed higher contact pressure right after fixation and through all intervals across the 60-minute test
- The DR group showed significantly more contact pressure and area at each abduction position with the applied load

The findings suggest that the DR construct offers superior contact performance during early rehabilitation programs with abduction exercise.

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Wrist Joint Research

CITATION: Daly B.T., et al, "Effect of Push-Up Position on Wrist Joint Pressures in the Intact Wrist and Following Scapholunate Interosseous Ligament Sectioning" (2018). The Journal of Hand Surgery, Vol 43, No. , pp. 339-345

Note: Image shown is meant to be representative, and is unrelated to research cited on this page.

Background: Damage to the scapholunate interosseous ligament (SLIL) has been shown to alter scaphoid and lunate kinematics, which are important for wrist motion and loading. Little is known about the contact pressures in the wrist joint during a push-up, when greater loading may occur during many activities. The purpose of this study was to determine contact pressures between the scaphoid and lunate, and the distal radius.

Testing Procedure:

- Eight cadaver wrists (average 78 years of age) were pinned at 65° angle (or maximum, if unable) of pronation with the elbow attached
- A dorsal incision was made to access the radioulnar carpal joint to insert a **K-Scan sensor**
- Pressure measurements were recorded with the wrist extended and in knuckle position
- Each wrist was loaded with an axial force equal to 50% of each specimen's body weight
- Data was acquired with the SLIL intact, and following sectioning of its dorsal, volar, and proximal components
- Peak pressure in each fossa, amount of area in each fossa exposed to loading, and the weighted centroid of pressure was computed at maximal wrist loading

Results: A push-up performed with the wrist in extension caused significantly greater peak pressure in the radioscaphoid fossa ($p = 0.001$) but not in the radiolunate fossa ($p = 0.54$). According to the researchers, this finding may help explain why degenerative arthritis first develops in the radioscaphoid fossa before involving the radiolunate fossa.

Also, a push-up in extension may be detrimental in the long-term.

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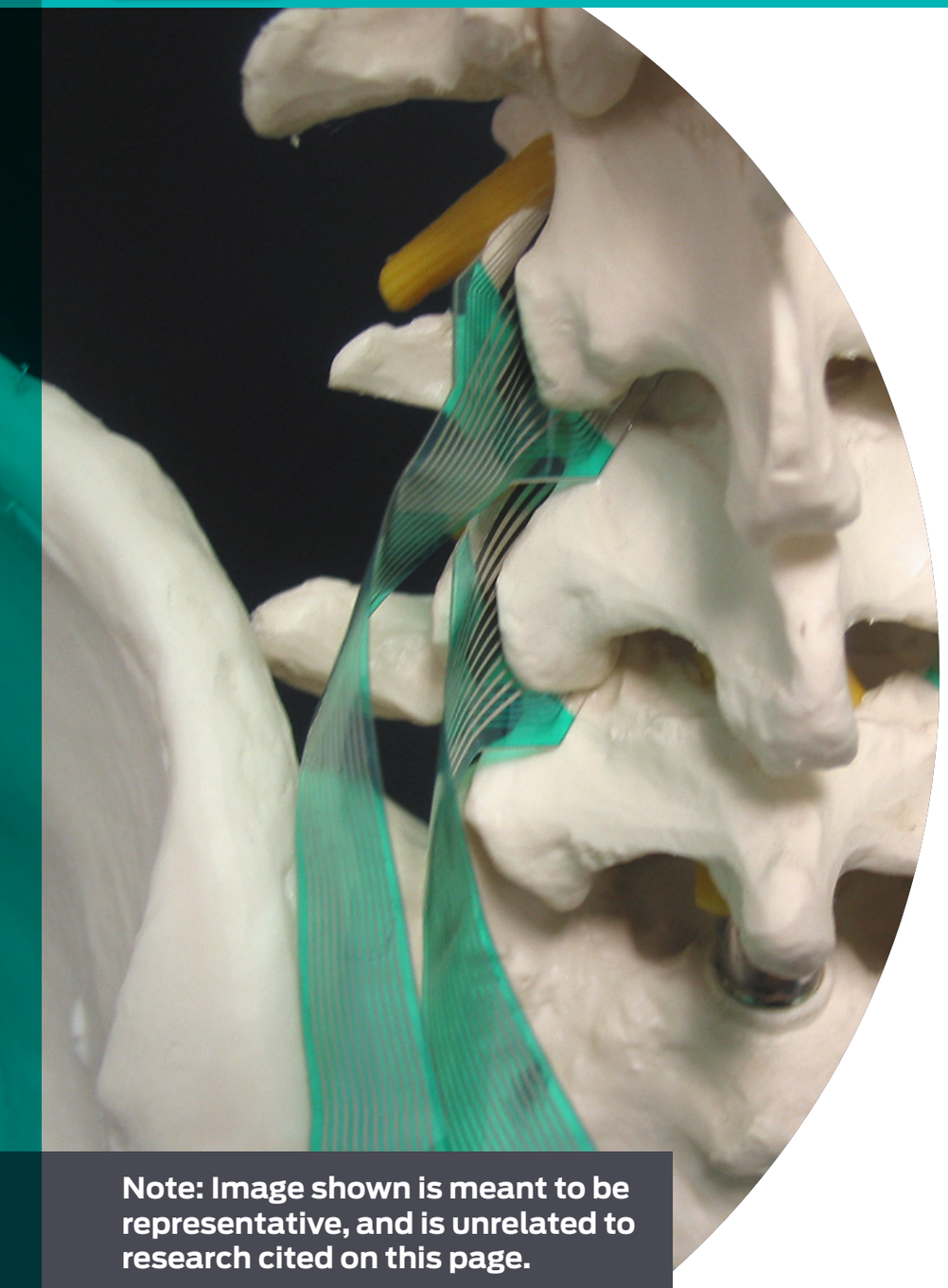
Hip Joint Research

CITATION: Bullock, W., et al "Quantifying the Force Transmission Through the Pelvic Joints During Total Hip Anthroplasty: a Pilot Cadaveric Study" (2018) Clinical Biomechanics. Vol 58. pp. 69-73



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Background: Total hip arthroplasty (THA) is one of the most effective procedures in orthopedics. However, some patients may report lower back pain after hip replacement, likely due to leg length discrepancy, altered femoral offset, unrecognized spinal abnormalities, and muscle deconditioning. However, it has been suggested that patients can develop sacroiliac joint (SIJ) pain after THA.

As a result, this cadaver study was conducted to quantify forces transmitted through the pelvis by measuring resultant forces at the SIJs and pubic symphysis (PS) during impaction of a press-fit acetabular component.

Testing Procedure:

- A solid design acetabular component was impacted into five human cadaver pelves with intact soft tissues.
- Following exposure of the joint, a 1/4 in. osteotome was gently inserted into the middle portion of each SIJ, as well as the PS, in order to place a **K-Scan sensor** within the pelvic contacts
- Forces were analyzed as a peak force over an entire trial, and peak force during each hammer strike; one light hammer, and one heavier hammer

Results: It was determined highly unlikely that forces experienced at pelvic joints are large enough to contribute to SIJ and PS pain during impaction. However, the results suggest that more force is conveyed to the PS compared to the SIJ, though not considered statistically significant. As per the results, while impacts may not be the primary factor contributing to SIJ pain after THA, the researchers suggested further research will be needed.

The paper cited the K-Scan system proved useful for placement within the irregular topography of the SIJs.

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Knee Joint Research

CITATION: Yang, J. S., M.D., et al "Patellofemoral Contact Pressures After Patellar Distalization: A Biomechanical Study" (2017) Arthroscopy: The Journal of Arthroscopic and Related Surgery, Vol 33, No. 11, pp. 2038-2044

Note: Image shown is meant to be representative, and is unrelated to research cited on this page.

Background: Iatrogenic patella baja is a challenging clinical problem that causes debilitating knee pain. Common causes are excessive tibial tubercle distalization, scarring from patellar tendon harvest after anterior cruciate ligament (ACL) reconstruction, and an overly-tightened patellar tendon repair.

In this study, researchers measured the patellofemoral contact pressure in early flexion after a tibial tubercle distalization osteotomy.

- Ten matched-pair fresh-frozen cadaveric knees were studied (mean age of 69 years). Only knees without previous surgery or radiographic arthritis were selected
- Knees were mounted onto a testing apparatus using a clamp, and secured with a metal pin
- A **K-Scan 4000 sensor** (two separate sensing regions) was used to measure the patellofemoral joint contact pressure.
  - Sensors were inserted through an incision in the supratrochlear capsule after calibration

Testing Procedure:

- Ten cycles of knee flexion-extension were performed. Contact force, area, and pressure measurements were recorded at 10° increments from 0°-to-30°, then 45°, 60°, and 90°

Results: The K-Scan readings indicated increased patellofemoral contact pressures at 0° and 10° as a result of excessive patellar distalization. The results showed increases in both contact area and contact force resulting from distalization osteotomy with their model.

- No changes were seen in contact pressure from 20° to 90°

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Ankle Joint Research

CITATION: Malekzadeh, S., et al "The Effect of Isolated Weber B Fibular Fracture Displacement on Tibio-Talar Contact Pressures" (2017) 41st Annual Meeting of the American Society of Biomechanics, Boulder, CO, USA

Note: Image shown is meant to be representative, and is unrelated to research cited on this page.

Background: Controversy exists as to whether surgery is necessary for Weber B ankle fractures, where the lateral malleolus is fractured and displaced without clinically significant talar shift or medial ankle disruption. As a result, the purpose of this study was to measure the contact areas and peak pressures between the tibial plafond and the talar dome in a cadaveric model with serial displacement of the distal fibula in two isolated Weber B fracture patterns:

- A transverse fibular fracture, and
- A short oblique fibular fracture

Testing Procedure:

- Twelve fresh cadaveric ankle specimens with no prior history of trauma were involved in the study
- The proximal tibia was potted in a PVC tube, and mounted onto a Mini Bionix® loading machine, which would press 70 kg of axial compressive load
- A **K-Scan sensor** inserted into the ankle joint and was used to monitor pressure distribution on the contact area
- The testing parameters were:
  1. Static, axial load at neutral position
  2. 5° and 10° dorsiflexion
  3. 5°, 10°, 15°, and 20° plantarflexion using an angled platform
- Then, one sample was randomly selected from each pair to simulate Weber B fractures with
  - Transverse fracture (TV) conditions
  - Spiral oblique (SR) conditions
- These samples were subjected to the same static, axial load, and positions, as the intact specimens for analysis

Results: The study suggests that isolated Weber B fractures' variables used in this study (lateral displacement up to 6mm; superolateral displacement up to 4mm lateral translation; 10° external rotation) did not cause ankle instability. This ultimately mitigates the need for surgery.

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Animal Joint Research

CITATION: Pedersen, D.R., et al "An Anterior Partial Meniscectomy Changes Joint Contact Mechanics in a Large Quadrupedal Animal Model of Osteoarthritis" (April 2016) Osteoarthritis and Cartilage. Vol 24, Supplement 1. pp S393-S394

Note: Image shown is meant to be representative, and is unrelated to research cited on this page.

Background: Many ACL tear injuries will also include meniscal damage, which can affect knee-contact mechanics. Studying progression of post-traumatic osteoarthritis (PTOA) after a joint injury in a large animal enables monitoring of joint health with clinical imaging techniques. This study tested a simple, reproducible method to surgically create abnormal contact mechanics without dramatically destabilizing the joint in a large survival animal model of PTOA.

Testing Procedure:

- Five sheep knees were dissected to expose an intact capsule. The knee was positioned 60° of flexion and potted
- Anterior and posterior incisions were made to insert a **K-Scan sensor**, while the knee ligaments remained intact
- Specimens were mounted onto a custom fixture that placed a 900 N load
- A 5mm wedge was removed from the anterior horn of the medial meniscus, and a load was reapplied
- Pressure data was loaded into a program to calculate
  - Medial and lateral compartment peak stress
  - Contact area
  - Centroid of contact patch, and
  - Center of pressure proportional to contact area

Results: Despite some limitations, the researchers determined that the anterior partial meniscectomy (APM) procedure alters contact stress magnitude and location to an extent that it would be expected to lead to PTOA.

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CONCLUSION

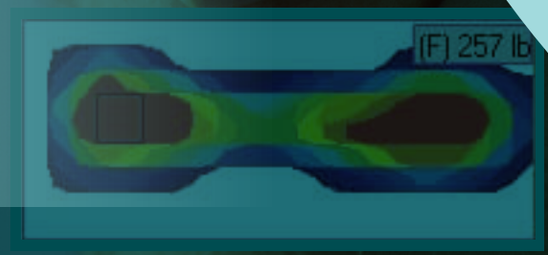
How Can Your Research Benefit from Actionable Joint Analysis Technology?

No matter your research goals, K-Scan provides objective data for quantified analysis that delivers results. Unique insights from these systems help researchers identify asymmetries and abnormalities that may otherwise go undetected by visual observation.

K-Scan Benefits:

- Thin, flexible, and trimmable sensors
- Provides direct measurement of contact mechanics over time; other technologies can only capture peak pressure
- Robust analysis software and reporting capabilities, including ASCII

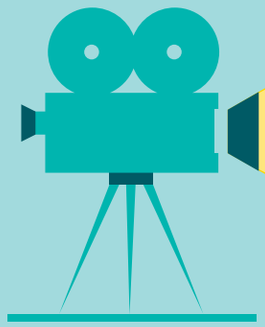
For more ways Tekscan technologies have been used in human and veterinary joint research, review our extensive up-to-date bibliography.



Let's start a conversation.

We at Tekscan understand the challenges researchers have when it comes to obtaining actionable joint pressure and contact data. Our representatives are standing by with tools to help you capture insights that will make your research a game-changer.

Visit www.tekscan.com/medical or call 1.617.464.4282 for more information.



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