Combined arthroscopic resection with repair of joint capsule using tendon flap of medical head of gastrocnemius for treating popliteal cyst

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Background

The treatment of popliteal cyst of the knee remains a clinical challenge, and clinical data are lacking. This study was to investigate the methods and the effectiveness of arthroscopic treatment combined with repair of the cyst wall using the tendon flap of medial head of gastrocnemius after resection of popliteal cyst.

Methods

A retrospective analysis was made on the clinical data of 140 patients with popliteal cyst between August 2009 and June 2014, including 44 males and 96 females with a mean age of 54.68 years (range, 14-80 years). The median course of symptoms was 31 months (range, 20 days to 30 years). According to Rauschning and Lindgren criteria for popliteal cyst grade, 4 cases were rated as grade I, 44 cases as grade II, and 92 cases as grade III. The preoperative Lysholm knee score was 68.99±8.23. Firstly, cyst was resected, then the hernia sac of joint capsule was repaired with the tendon flap of medial head of gastrocnemius muscle, and finally a knee arthroscopy was used for the diagnosis and treatment of intra-articular lesions.

Results

No complication of nerve or blood vessel injury, infection, or necrosis occurred. The mean follow-up was 26 months (range, 6-64 months). During follow-up, 1 case (0.71%) had cyst recurrence. According to Rauschning and Lindgren criteria for popliteal cyst grade, 37 cases were rated as grade 0, 92 cases as grade I, 10 cases as grade II, and 1 case as grade III at 6 months after operation, showing significant difference when compared with preoperative one (P<0.01); the Lysholm knee score (85.51±9.23) was significantly higher than preoperative score (P<0.01).

Conclusion

Arthroscopic treatment combined with repair of the cyst wall with the tendon flap of medial head of gastrocnemius muscle after resection of popliteal cyst is a better way to avoid recurrence.
Arthroscopic management for hip acetabular labral tears
-A retrospective study for 300 hip arthroscopy surgery cases

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Abstract: Purpose Several studies have recently found an association between acetabular labral tears and the early onset of osteoarthritis. For this reason, treatment of labral tears in young and active patients is crucial for hip preservation. We retrospective reviewed 300 cases for hip acetabular labral tears that treated with hip arthroscopy surgery. The clinical results and image evaluation results were analyzed. Method From Mar 2007 to May 2013 ,300 consecutive cases of hip acetabular labral tears were treated with hip arthroscopy surgery ,we divided there cases to 4 groups:1.Acute hip trauma. 2.Acetabular labral tears combined with Femoroacetabular impingement (FAI) 3.Acetabular labral tears combined with bonderary hip dysplasia.(CE angle 20°-25°)  4.Acetabular labral tears combined with severe hip dysplasia(CE angle <20°). All the patients were evaluated by clinical examination, X ray film, MRI. The mean follow up time was 3.6 years (2-5 years). Results For Acute hip trauma cases,36 patients were included. We performed hip arthroscopic surgery that including loose body removal and debridement of the labral tears. Two of the patients were treated with internal fixation of the posterior wall fracture of acetabular rim and labral repair under arthroscopic surgery. The mean modified harris score(MOS) was improved significantly from 56.2±4.8 pre-operatively to 95.6±3.7 post-operatively. (P<0.01). For FAI cases, 234 patients were included. All the patients were treated with acetabular rim trimming and osteoplasty of femoral neck and head junction under arthroscopy surgery.168 patients were treated with labral repair and 66 patients were treated with labral tears debridement. The mean MOS of the labral repair group was significantly improved from 68.3±3.4 pre-operatively to 97.4±2.8 post-operatively. (P<0.01).The mean MOS of the labral debridement group was significantly improved from 65.3±4.8 pre-operatively to and 95.4±4.1. (P<0.01). There was no significant different between the two groups.(P>0.05). For acetabular labral tears combined with bonderary hip dysplasia cases(CE angle 20°-25°).25 patients were included. All the patients were treated with labral repair under arthroscopy surgery. The mean MOS was improved significantly from70.1±2.8 pre-operatively to 98.3±4.3 post-operatively. (P<0.01). For acetabular labral tears combined with severe hip dysplasia cases(CE angle <20°), 5 patients were included. All the patients were treated with labral repair under arthroscopy surgery. The mean MOS was not significantly improved from 65.2±4.5 pre-operatively to 67.3±5.1 post-operatively. One 59 years old patients complicated with hip subluxation at 6 months after operation and revised by hip arthroplasty. The postoperative results were poor (P>0.05). Conclusion Hip arthroscopy surgery seems to be an effective method for treating hip acetabular labral tears cases for patients not combined with severe hip dysplasia. The mid-term results showed good improvement of the clinical evaluation no matter labral repair of debridement but not for the severe hip dysplasia cases.
A morphologic and quantitative comparison of mechanoreceptors in the tibial remnants of the ruptured human anterior cruciate ligament

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Abstract
Background: Reconstruction of the ruptured anterior cruciate ligament (ACL) does not always result in the expected successful outcome. A satisfactory outcome may depend not only on the tightness or strength of the graft but also on the quality of proprioceptive restoration. Mechanoreceptors of the ACL are supposed to play a considerable role in the proprioceptive feedback system of the knee. Our purpose was to observe the condition and number of the surviving mechanoreceptors in the tibial remnant of the ruptured ACL in human knees.
Method: From April 2009 to January 2014, sixty patients with existing free tibial remnants who had undergone arthroscopic ACL reconstruction were divided into 4 groups according to the time of injury. As control, six normal ACL specimens were taken. Specimens were obtained from ACL tibial remnant and stained by immunohistochemical staining method. The type, size, and quantity of mechanoreceptors were observed under light microscope.
Result: A total of 92 Ruffini-like corpuscles, 9 Pacini-like corpuscles, 5 unclassified neural endings and free nerve endings were identified via immunohistochemical staining. There were no statistical differences in the number of mechanoreceptors observed in the five groups (P=0.238). Some degenerative changes were observed in Group IV.
Conclusion: The results suggest that the residual mechanoreceptors in the ruptured ACL exhibit long-term survival and show no obvious signs of withering within 1 year. If the remnant is preserved during ACL reconstruction, it may provide a source of graft reinnervation and proprioceptive nerve fiber ingrowth, which may contribute to improved proprioceptive function and a successful clinical outcome.
The Study of Interleukin-8 on Anterior Cruciate Ligament Reconstruction with Remnant Preservation

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Objectives
Preservation of Remnant Attachment Improves Graft Healing in a Rabbit Model of Anterior Cruciate Ligament Reconstruction.
The aim of this study was to investigate the role of interleukin 8 between remnant preserved versus conventional anterior cruciate ligament reconstruction especially during the early stage.

Methods
40 cases of ACL reconstruction was studied. Group I was 20 cases of remnant preserving and group II was 20 cases of ACL reconstruction without remnant preservation. We collect the joint fluid from the patients every 3 months and Interleukin-8 was measured using Multiplex assay. Stability is measured by stress radiogram using Telos device at 30 flexion at post-operative 3, 6, 12 Month. ACL signal intensity on MRI after mean period 13 months (10–18 months) of operation was measured.

Results
At 3 Months, IL 8 was elevated in 55 % in group I & 25% in group II. Anterior displacement measured by stress radiogram using Telos was 0.46mm ± 0.19 in group I and 3.39mm ± 0.28 in group II at post-operative 3 Month, 1.15mm ± 0.25 in group I, 2.96mm ± 0.28 in group II at post-operative 6 month, 2.96mm ± 0.28 in group I, 2.87mm ± 0.34 in group II at post-operative 12 month, mechanical stability was better in group I than group II with statistical significance.
There was increased signal on F-up MRI in group II than group I with statistical significance.

Conclusions
The remnant preservation ACL reconstruction may be beneficial for ligamentization of the graft tendon during the first 3 months and for mechanical stability.
Keywords: Remnant preserving ACL reconstruction, interleukin 8, mechanical stability
A Morphologic and Quantitative Study of Mechanoreceptors in the Remnant Stump of the Human Anterior Cruciate Ligament

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Purpose: To investigate the morphology and quantity of mechanoreceptors in the remnant stumps of injured anterior cruciate ligaments (ACLs) and the association of the number of mechanoreceptors with the time from injury to surgery. Methods: Complete ACL stump specimens were collected from 40 volunteer patients who underwent arthroscopic ACL reconstruction surgery. Serial sections, 20 mm in thickness, were prepared from each specimen. After H&E staining and immunohistochemical labeling, the morphology, type, size, and quantity of the mechanoreceptors were observed under an optical microscope. Results: A total of 176 Ruffini corpuscles, 61 pacinian corpuscles, 15 Golgi-like tendon organs, and 66 atypical mechanoreceptors were observed. Free nerve endings were commonly present in the specimens. The time from injury to surgery (log₁₀ days) was negatively correlated with the number of total mechanoreceptors (r=0.43, P < .006), Ruffini corpuscles (r=0.45, P < .003), and the volume of the ACL stump (r=0.52, P < .01), and these correlations were independent of age, gender, injury side, and career. Conclusions: The number of mechanoreceptors in an ACL stump and the volume of the stump decreased with the time from injury to surgery.
Use of Estradiol Promotes Tendon Bone Healing in Rabbit Model

Underwent Anterior Cruciate Ligament Reconstruction

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Background: Anterior cruciate ligament (ACL) injury is a common injury of articular ligament with an incidence rate of 91 per 100,000 individuals, among which ACL reconstruction surgery is recommended for most of the patients hoping for a complete healing and heading back to the sports activity. Apart from autograft and allograft ligament, artificial ligament, considered as a promising graft in ACL surgery, is used in more than 10% ACL reconstruction surgery. Enhancement strategy in Polyethylene terephthalate (PET) artificial ligament graft ligamentization is a hot issue in sports medicine research. Estradiol has been used in osteoporosis treatment and shows its potency in bone formation. Given the research results previously, we hypothesized that use of estradiol may improve tendon bone healing in ACL reconstruction course.

Material and Method: In an in vitro study, MC3T3-E1 murine preosteoblast cell line is cultured with estradiol in gradient concentration and a contrast group without estradiol is cultured as well. Cell morphology, cell proliferation rate, cell bioactivity and ossification capacity, along with BMP-2, OPN, and OPG protein which are related with bone formation are gauged at different time point during cell culture. In an in vivo study, we perform ACL reconstruction with PET artificial ligament fabricated with LARS artificial ligament remnant in 24 New Zealand rabbits. Rabbits in experimental group take subcutaneous injection of estradiol every 3 day after surgery, while the control group take equivalent normal saline at the same time. Animals are scanned with X-ray computed tomography 2 weeks, 4 weeks, 8 weeks and 12 weeks after surgery to evaluate bone tunnel aperture. Phlebotomization and centrifugation are performed every week to test serum estradiol concentration level continuously. We sacrificed one third of the rabbit at 4 weeks, 8 weeks and 12 weeks separately for further study, including Micro-CT testing for bone density around bone tunnel, biomechanical tests focusing on ultimate failure load and stiffness, histology study with use of hematoxylin and eosin stain or Masson’s trichrome stain.

Results: In the in vitro study, the experimental group cultured with estradiol is superior to the control group in cell morphologic and proliferation test, cell bioactivity, ossification capacity. Western blot and Realtime-PCR revealed rises in BMP-2, OPN and OPG in estradiol group compared with that of control group. The trend is consistent with the increase concentration of the estradiol in cell culture. In the in vivo study, serum estradiol concentration goes up over time in estradiol group while the control group results stay still. Bone tunnel diameter shrinking and Hounsfield Unit up going are observed group over time in experimental and control group via CT scan. The former group results excel the latter one at 8 weeks and 12 weeks with statistical significance (P<0.05). The estradiol group species present higher ultimate failure load...
and stiffness in biomechanical testing. Micro-CT scanning at different timing shows increase in bone density in estradiol group which cannot be matched in that of control group. HE and Masson staining demonstrate the scar tissue thickness is smaller in the estradiol group compared with control group in 8 weeks and 12 weeks. Moreover, new bone tissue formation can be found in the estradiol group via Masson staining, reflecting bone formation in the interface.

**Discussion:** the results verify our hypothesis previously that the use of estrogen may promote tendon bone healing in anterior cruciate ligament reconstruction. As expected, Estrogen shows its ossification ability in vitro, inducing bone formation associated protein up regulation as detected in Western blot and Realtime PCR. In the in vivo study, the CT scan every 4 weeks combined with Micro-CT shows an upward trend in bone density and a downward trend in bone tunnel diameter and HU value as time goes by. The trend is more distinct in estradiol group than control group, indicating estradiol may promote bone formation in tendon healing period after ACL reconstruction. Biomechanical and stain results also support our hypothesis as shown in the results part. Uses of estrogen in bone formation research have been reported before, but its use in tendon to bone interference healing research lacks reports. Our job takes an intra-articular animal model instead of extra-articular ACL model to better mimic the ACL injury and surgery condition. Admittedly, the rise in serum estrogen concentration in estradiol group suggests that subcutaneous injection may lead to side effect in experimental animal to some extent, we believe that a new drug loading carrier that enables drugs like estradiol to be released at the certain location under control for a long time will be helpful in our further research.

**Conclusion:** use of estradiol improves ossification capacity in vitro and promote tendon to bone healing after anterior cruciate ligament reconstruction in vivo.
Background: Tendon-bone healing plays an important role after anterior cruciate ligament (ACL) reconstruction. The extracellular matrix (ECM) of organism is nanoscale, and by electrospinning, micro-/nanoscale scaffolds which have high porosity and surface area could be fabricated. It was demonstrated that compared with aligned electrospun mat, random electrospun mat could induce osteogenic differentiation of stem cells. Among the materials that can be electrospun, silk fibroin (SF) has drawn a great research interest because of excellent mechanical properties and biocompatibility. Based on the aforementioned information, we hypothesize that random electrospun SF mat wrapping could enhance tendon-bone healing of autograft. Material: Cocoons of Bombyx mori silkworm and 32 New Zealand white rabbits (mean weight 2.8 ± 0.5 kg) were used in the study. Method: The random electrospun SF mats were made from aqueous solution of regenerated SF. The New Zealand white rabbits were randomly divided into electrospun SF mat group and control group. After anesthesia, a 2-cm-long partial-thickness Achilles tendon of right lower limb was harvested and a bone tunnel was made in the proximal tibia of left lower limb at 60° angle to the vertical axis of the tibia by a 2.5 mm diameter kirschner wire. In electrospun SF mat group, the harvested Achilles tendon wrapped by electrospun SF mat was implanted into the bone tunnel, while in control group, the Achilles tendon without wrapping was implanted into the bone tunnel. After the operation, the rabbits were allowed to move freely in their separate cages without immobilization. The rabbits were sacrificed at 6 and 12 weeks postoperation for gross observation, histological observation and biomechanical tests. Results: The electrospun SF mats were unidentifiable already at 6 weeks postoperation. Histological hematoxylin-eosin (HE) staining showed that at 6 weeks after surgery, the collagen fibers of the tendon-bone interface in electrospun SF mat group were organized while those in control group were chaotic. At 12 weeks after surgery, the tendon-bone interface in electrospun SF mat group became much narrower compared with that in control group, indicating new bone had grown into the transplanted Achilles tendon. At both 6 and 12 weeks after surgery, electrospun SF mats were not observed in electrospun SF mat group, indicating that the mats were absorbed already. Mechanical tests showed that at both 6 and 12 weeks after surgery, the failure loads of electrospun SF mat group were significantly higher than that of control group (P < 0.05). Discussion: It was demonstrated that periosteum wrapping could enhance tendon-bone healing and decrease bone tunnel enlargement. However, the harvest of periosteum will lead to the injury of donor site and prolong the operation time. In this study, we demonstrated that the random electrospun SF mat could enhance tendon-bone healing. So the electrospun SF mat could substitute periosteum to promote tendon-bone healing after ACL reconstruction, showing great clinical application potential. However, we did not compare the effects of electrospun SF mats with periosteum on tendon-bone healing, so which one was better remained unclear. The electrospun mats are excellent vehicles to deliver drugs, so the electrospun SF mats with osteogenic drugs could be researched in future. Conclusion: In this study, we demonstrated that the random electrospun SF mat wrapping autograft could enhance tendon-bone healing.
Long-term Effects of Knitted Silk-collagen Sponge Scaffold on Anterior Cruciate Ligament Reconstruction and Osteoarthritis Prevention

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Background: Anterior cruciate ligament (ACL) is difficult to heal after injury due to the dynamic fluid environment of joint. Previously, we have achieved satisfactory regeneration of subcutaneous tendon/ligament with knitted silk-collagen sponge scaffold due to its specific "internal-space-preservation" property. This study aims to investigate the long-term effects of knitted silk-collagen sponge scaffold on ACL regeneration and osteoarthritis prevention. Material and Method: The knitted silk-collagen sponge scaffold was fabricated and implanted into a rabbit ACL injury model. Results and Discussion: The knitted silk-collagen sponge scaffold was found to enhance migration and adhesion of spindle-shaped cells into the scaffold at 2 months post-surgery. After 6 months, ACL treated with the knitted silk-collagen sponge scaffold exhibited increased expression of ligament genes and better microstructural morphology. After 18 months, the knitted silk-collagen sponge scaffold-treated group had more mature ligament structure and direct ligament-to-bone healing. Implanted knitted silk-collagen sponge scaffolds degraded much more slowly compared to subcutaneous implantation. Furthermore, the knitted silk-collagen sponge scaffold effectively protected joint surface cartilage and preserved joint space for up to 18 months post-surgery. Conclusion: These findings thus demonstrated that the knitted silk-collagen sponge scaffold can regenerate functional ACL and prevent osteoarthritis in the long-term, suggesting its clinical use as a functional bioscaffold for ACL reconstruction.
Research of biocompatibility of PET artificial ligament modified by silk fibroin coating in vitro and in vivo

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Background To investigate the effect of silk fibroin (SF) coating for the cell compatibility in vitro of polyethylene terephthalate (PET) material and for the ligamentization of intra-articular segment in vivo of PET artificial ligament.

Methods The surface of PET artificial ligament was treated by plasma, and then PET artificial ligament was soaked in an SF solution. BALB/C CL7 mice ligament fibroblasts was cultured in the uncoated-PET material (control group), SF coating-PET material (SF group). Subsequently, scanning electron microscope (SEM), methyl thiazolyl tetrazolium (MTT), cell cycle analysis, collagen protein and DNA content was detected. Furthermore, the mRNA expression levels of fibronectin (FN), β-actin, integrin α1 and integrin β1 were also detected. Intra-articular segment of PET artificial ligament was coated by SF, which was used to reconstruct Beagles’s anterior cruciate ligament (ACL). The coverage of intra-articular synovial tissue covering the artificial ligament was assessed.

Results The results of SEM, MTT and cell cycle analysis showed SF group could significantly improve the proliferation of BALB/C CL7 mice ligament fibroblasts (P<0.05). Collagen protein and DNA content analysis showed that the specific surface area was increased by 3D structure in the SF group (P<0.05), which provides a good growth substrate for the high density culture of BALB/C CL7 mice ligament fibroblasts. mRNA expression analysis of FN, β-actin, integrin α1 and integrin β1 showed that the normal BALB/C CL7 mice ligament fibroblasts related gene expression was not changed in the PET-SF composite materials (P>0.05). One month after ACL reconstruction, synovial tissue coverage in the SF group and control group was 85.4 ± 4.3% and 62.8 ± 5.7%, respectively (P <0.05). Moreover, three months after ACL reconstruction, synovial tissue coverage in the SF group and control group was 97.7±2.1%% and 92.5 ± 4.3%, respectively (P>0.05).

Conclusion PET-SF composite materials has good cell biocompatibility in vitro. ACL reconstruction in vivo confirmed that the SF coating could improve the coverage of intra-articular synovial tissue covering the artificial ligament early, which speeds up the process of ligamentization.
Injectable Simvastatin Thermogel Promote PET Artificial Graft-Bone Healing On Rabbit ACL Reconstruction Model

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Enhancement of polyethylene terephthalate artificial ligament graft osseointegration using a periosteum patch in a goat model

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Abstract

Purpose: to investigate whether a periosteum patch could enhance polyethylene terephthalate (PET) artificial ligament graft osseointegration in bone tunnel.

Methods: Twelve female goats underwent ACL reconstruction with PET artificial ligament graft in the right knees. Right knees in six goats were reconstructed with periosteum patch enveloped PET grafts (Periosteum group) in the tibia bone tunnel, whereas the other six goats had no periosteum patch made as the control group. All the goats were sacrificed at 12 months after surgery. Three tibial-graft complex samples in each group were harvested for microcomputed tomography (micro-CT) scan, magnetic resonance imaging (MRI) scan and histological evaluation consecutively. The other three tibial-graft complex samples in each group were harvested for biomechanical testing.

Results: The mean pull-out load of the Periosteum group at 12 months was significantly higher than that of the control group ($p < 0.05$). According to micro-CT scan, more new bone formation was observed at the graft-bone interface in the Periosteum group compared with the control group. Furthermore, MRI showed that the Periosteum group appeared to have a better graft osseointegration within the bone tunnel compared with the control group. Histologically, application of periosteum patch induced more new bone and Sharpey's fiber formation between graft and bone tunnel compared with the controls.

Conclusion: The study has shown that periosteum enveloping on the PET artificial ligament has a positive effect in the induction of artificial ligament osseointegration within the bone tunnel.

Key Words: polyethylene terephthalate; periosteum; osseointegration; artificial ligament; ACL
The Experiment Research Of Anatomic Anterior Cruciate Ligament

Reconstruction Assisting By 3D Printing Technology

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Background: Due to the individual differences of diameter and print of ligament, the requirements of individual anatomic precise reconstruction can not be meted with traditional single positioning method. 3D printing technology may can help with this problem.

Method: The body knees are scanned with thin layer CT aimed to gain the data of bones which is used to establish knee joint model by computer software. The site and direction of the bone tunnels of femur and tibia is designed and calibrated on the knee joint model. The knee resin mold and ACL navigation template is replicated with the help of 3D printing, the accuracy of which is validated on the body knees.

Results: The internal opening of femoral and tibial bone tunnel is located in the central point of original ligament footprint area, and the site and direction is same as preoperative design.

Discussion: Anatomic single bundle ACL reconstruction assisting by 3D printing can greatly improve the accuracy of positioning and short the time of operation by means of careful preoperative design and preview.

Conclusion: This method of positioning is accurate, reliable and repeatability, which is expected to improve the success rate of ACL reconstruction and is feasible for further clinical research.
Dual-Energy CT Staining Technique: Detecting Knee Sports Injury-Feasibility Study

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Abstract

Objective: To evaluate sports injury with a dual-energy (DE) computed tomographic (CT) staining technique.

Methods: In this prospective institutional review board–approved study, 40 patients with sports injury underwent DE CT and arthroscopy. A software application was used to staining. Presence of cruciate ligament or meniscus injury were noted, and Presence of site was noted too by two radiologists, with arthroscopy serving as the reference standard.

Results: Agreement of DE-CT with arthroscopy was good in the anterior cruciate ligament (κ=0.77), moderate in the lateral meniscus and medial meniscus (κ=0.41; κ=0.60), and excellent in posterior cruciate ligament (κ=1). Accuracy was 95%, 70%, 80% and 100% for the respective tissue. For cruciate ligament observer 1 achieved a sensitivity of 100%, a specificity of 95.7%, a positive predictive value of 83.3%, a negative predictive value of 100%, and an accuracy of 97.5%. Observer 2 achieved values of 100%, 97.8%, 97.1%, 100%, and 98.7%, respectively. For meniscus observer 1 achieved a sensitivity of 72.2%, a specificity of 77.3%, a positive predictive value of 72.2%, a negative predictive value of 77.3%, and an accuracy of 75%. Observer 2 achieved values of 83.3%, 79.5%, 76.9%, 85.4%, and 81.3%, respectively.

Conclusion: This DE CT staining technique allowing cruciate ligament and meniscus assessment and potentially making sports injury of the knee detectable with CT.

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USE OF PORTABLE MOTION ANALYSIS SYSTEM FOR KNEE STABILITY ASSESSMENT IN ACL DEFICIENCY DURING SINGLE-LEG-HOP

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Background:
Anterior cruciate ligament (ACL) rupture is one of the most common sports injuries. Deterioration in function ensues as knee stability is compromised. Clinical assessment after an ACL injury mainly comprises of passive laxity tests, such as the Lachman test and the pivot shift test, both of which rely on the assessor’s subjective judgement and do not correlate well with function. Knee stability involves several components; hence, a disruption in the structural integrity does not always result in instability. Altered kinematics has been observed in ACL-deficient knees. The measurement of kinematics may provide a better assessment for knee stability. However, conventional motion analysis systems used for kinematic measurements are not readily available in the clinical setting due to its size and labor requirements. Therefore, we examine the use of a newly developed portable motion capture system (Opti-Knee®, Shanghai Innomotion Inc., China) to evaluate knee kinematics in ACL-deficient patients. Based on previous studies, we hypothesize that the Opti-Knee® will be able to differentiate between ACL-deficient knees and uninjured knees.

Material:
Ten ACL-deficient subjects and 10 healthy controls were recruited. Tibiofemoral kinematics was measured using the Opti-Knee® system. The system consists of a portable workstation fitted with 1 high speed camera and two infrared cameras approximately 50cm apart on a movable arm. Eight markers were attached to each limb according to a pattern provided by the developer.

Method:
Subjects were instructed to perform five trials of single leg hops forward from a marked starting position to another marked position 1 meter away with both arms across the chest. The IKDC, Tegner, and Lysholm scores were also obtained. Kinematic data for flexion/extension, varus/valgus, internal/external tibial rotation, anteroposterior translation, and mediolateral translation were obtained for the period between initial contact – when any part of the foot touches the ground – and the end of force absorption phase – maximum flexion immediately after initial contact. Intra-individual repeatability was measured by calculating the pooled standard deviation. Variability of the kinematic measures was evaluated with coefficient of variation (CV). Side-to-side differences (SSD) were calculated as injured minus non-injured side in the ACL-deficient group and right minus left in the control group. Non-parametric two-related samples Wilcoxon signed-rank test was used to compare within subject differences. Mann-Whitney test was done to compare SSD between ACL-deficient subjects and controls. Statistical analysis was done using SPSS at an alpha level of 0.05.

Results:
ACL-deficient subjects have significantly lower IKDC, Tegner, and Lysholm scores compared to the control group. There were no significant differences between the two groups in age, sex, weight, and height. One ACL-deficient subject was unable to perform the single leg hop. Sudden changes in internal/external rotation, anteroposterior translation, mediolateral translation were detected immediately after initial contact. Intrapersonal task variation was small between initial contact and impact absorption phase and large before take-off and after impact absorption. ACL-deficient knees exhibited a significantly lower knee flexion range of motion (p=0.008) and internal/external rotation range of motion (p=0.038) compared to the non-injured limb. No significant differences were seen
in the other kinematic measures and in the control group. SSD in knee flexion range of motion was significantly lower in the ACL-deficient subjects compared to the controls (p=0.002). A trend toward significant difference was seen in SSD of internal/external rotation range of motion.

Discussion:
Our results indicate that the Opti-knee is able to detect kinematic differences between ACL-deficient knees and uninjured knees during a single leg hop task. The single leg hop is a well-accepted test to evaluate function after ACL injury. It has been reported to be sufficient to provoke kinematic alterations between ACL compromised knees and uninjured knees [1]. Our results are in line with previous kinematic studies in flexion range of motion and internal/external rotation range of motion [2]. However, a recent study that used a similar test protocol reported greater anterior tibial translation compared to uninjured knees, which our study failed to replicate [3]. The discrepancy between the two studies may have been due to the subject heterogeneity of the current study since we included subjects with meniscal injuries. Furthermore, our study did not employ a strict protocol as some of our subjects had lower activity levels. Subjects who were hesitant to perform the task with the 1 meter distance were allowed to perform the task at a self-selected distance. This is likely a protective response to control for excessive knee joint motion during landing. Despite the weaknesses of skin-based motion capture, Oberlander reported low variability while our study has a much larger coefficient of variation [3]. Subject heterogeneity and variations in hop distance are the likely causes.

Conclusion:
The current study suggests that the altered knee kinematics in ACL-deficient subjects can be measured by the Opti-Knee. The development of a portable motion analysis system enables for the clinical application of a kinematic assessment tool, which up to this point has been mainly used in the research setting, as a potential first screening tool for suspected ACL injured patients.

References:
Background: Anterior cruciate ligament (ACL) disruption is one of the most common incidents found in knee injuries, accounting for up to 40% in sports injuries [1]. Serving as the connective tissue which spans from the femur to the tibia, the ACL plays an important role to stabilize joint movements by prohibiting the tibia from excessive anterior translation and rotational movements. Hence, an injury to the ACL is expected to deteriorate knee joint stability. Currently, clinical evaluation of knee laxity after an ACL injury mainly involves passive tests such as Lachman and pivot shift test [1]. These passive tests are influenced by the subjective perception of the assessor and do not correlate well with functional outcomes [2]. Kinematic measurement with the use of a motion capture system can serve as a complementary approach to evaluate knee joint kinematic alterations in ACL-deficient patients. Conventionally, motion analysis system is not used in clinical settings due to their stringent requirements – multiple camera installation, space consumption, and laborious calibration procedures. In this study, we measured knee kinematic using Opti-Knee®, a portable and user-friendly motion capture system (Shanghai Innomotion Inc., Shanghai, China), which was developed for clinical use. The aim of this study is to assess the joint kinematic alterations in ACL injured patients using a portable motion capture system during a stair descending task, which is often encountered in daily activities.

Material: A total of 12 healthy subjects and 12 ACL-deficient patients with or without concomitant meniscal injuries were included in this study. Tibiofemoral joint kinematics was measured using Opti-Knee® system. The system consists of a portable workstation fitted with 1 high speed camera and two infrared cameras approximately 50cm apart on an adjustable arm. Eight reflective markers were placed on the lateral side of the lower limb along the thigh and calf, depicting the location and orientation of the femur and the tibia.

Method: Participants were instructed to perform the stair descending task in a reciprocal gait pattern from a 2-step staircase with 20cm step height. The pace was synchronized to an 80Hz beat using a metronome. Opti-Knee® was used to record coordinate data from the eight reflective markers. Before recording the motion task, simple calibration was performed to identify the essential anatomical landmarks. Three successful trials were acquired for each subject. Knee kinematics for each frame throughout the motion task was calculated from relative changes in geometrical coordinates of the reflective markers compared to the calibrated femur and tibia coordinate systems.
The knee kinematics between two subsequent foot strikes of the test leg was considered as a complete gait cycle. Paired t-test was used to evaluate kinematic variables between both limbs within each subject group, whereas independent t-test was used to measure side-to-side difference between two subject groups. Statistical analysis was conducted using SPSS with significance level set at 0.05.

Results: Kinematic data for flexion/extension, varus/valgus, internal/external tibial rotation, anteroposterior translation, and mediolateral translation were obtained and analyzed. Statistically significant side-to-side difference in internal rotation of the tibia was found between ACL deficient patients and healthy controls, with 6 out of 12 ACL-deficient patients exhibiting higher internal tibial rotation on the injured side. No significant differences were seen in the other kinematic measures and in the control group.

Discussion: The results from this study suggest that the current optoelectronic motion analysis system is able to detect kinematic differences between the ACL-deficient knee and healthy knees. A tibial internal rotation pattern was identified in ACL-deficient knees during stair descent. This finding was in line with a previous kinematic study that reported similar kinematic outcome [3]. However, we did not find reduced extension and increased knee varus in ACL-deficient knees as reported in the same study. This discrepancy may be due to subject heterogeneity of the current study as subjects with meniscal injuries were included. Furthermore, no limit was imposed on duration between injury and assessment during subject recruitment. Several of our subjects had injury to assessment duration of over one year, which may have provided ample time to cope well enough with the injury during the performance of low demand tasks. Stair descent is considered a less strenuous biomechanical task as compared to other conventional tests such as the single leg hop. This task was selected as it is appropriate for patients who refuse or who are unable to perform the single leg hop due to apprehension or fear. Hence, kinematic difference may not be as pronounced. Nonetheless, our results show that stair descent may be sufficient when comparing ACL-deficient knees with uninjured knees.

Conclusion: The current study suggests that altered knee kinematics in ACL-deficiency can be observed by using the Opti-Knee® during stair descent. Although other motion tasks may elicit more observable changes in kinematics, stair descent is sufficient and appropriate for those who are unable to perform more challenging tasks. The system is portable and easy to use, making it appropriate for use in the clinical setting compared to conventional motion analysis systems.

References:

Gait modification strategies in trunk over right stance phase in patients with right anterior cruciate ligament deficiency

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Background: To investigate gait modification strategies of trunk over right stance phase in patients with right anterior cruciate ligament deficiency (ACL-D).

Material: Thirty-six patients with right chronic ACL-D and 36 controls were recruited.

Method: A 3D optical video motion capture system was used to record coordinate data from reflective markers positioned on subjects during gait and stair ambulation. Kinematic variables of the trunk and kinematic and kinetic variables of the knee were calculated.

Results: Patients with chronic right ACL-D exhibited many significant abnormalities compared with controls. Trunk rotation with right shoulder trailing over right stance phase was lower in all five motion patterns ($P<0.05$). Compared with controls, trunk posterior lean was higher from descending stairs to walking when knee sagittal plane moment ended ($P<0.01$); trunk lateral flexion to the left was higher when ascending stairs at the start of right knee coronal plane moment ($P=0.01$), when descending stairs at the maximal knee coronal plane moment ($P<0.01$), and when descending stairs at the end of the knee coronal plane moment ($P=0.03$); trunk rotation with right shoulder forward was higher at the minimal knee transverse plane moment ($P<0.01$) and when the knee transverse plane moment ended ($P<0.01$) during walking, trunk rotation with right shoulder trailing was lower at other knee moments during other walking patterns (all $P<0.01$).

Discussion: These findings suggest that gait modification strategies of the trunk were apparent in patients with right ACL-D. Conclusion: Results supply more insights with respect to improving the diagnosis and rehabilitation of chronic ACL-D including better use of walking and stair tasks as part of a rehabilitation program.

Keywords: anterior cruciate ligament deficiency; trunk; kinematics; kinetics; gait modification strategy
Reliability and minimum detectable change of knee kinematics and kinetics during sidestep cut in female

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Background: Anterior Cruciate Ligament (ACL) injuries are serious and relatively common in sports [1]. Female athletes are two to six times more likely than males to sustain an ACL injury [2]. The knee valgus angles and knee abduction moments measured in vertical drop jumps have been suggested to predict ACL injury [3]. The vertical drop jump test was further used for screening athletes with high risk of ACL injury [4]. However, a recent study argued that sidestep cutting may be more relevant for screening efforts [5].

For use as an evaluative measure, the test must demonstrate high reliability based on the subject variations and the ability to classify subjects. There is no information regarding the reliability of discrete variables such as the peak value and the range of motion. The reliability can be obtained by calculating the standard error of measurement (SEM) and the minimum detectable change (MDC) which are recommended be reported for clinical practice [6]. The MDC is the smallest measured change that can be interpreted as a true difference. Estimates of SEM and MDC enables the researcher to judge whether the change measured in the sidestep cutting, as indicated by kinematics and kinetics measures, represents a true difference between subjects. The objectives of the present study were to evaluate the inter-trial and inter-session reliability of the knee kinematics and kinetics in sidestep cutting task, and to determine the minimum detectable change in female elite handball and football players.

Material: Nineteen female handball players and 22 female football players (21.6±4 years old, 168±5 cm, 66±8 kg) were tested (n = 41).

Method: The subjects were tested twice by the same personnel, using identical laboratory settings with one to three weeks interval. The subjects performed five trials of sidestep cuttings with match-like intensity in a biomechanics laboratory. Sixteen 480 Hz infrared cameras (Oqus, Qualisys, Gothenburg, Sweden) recorded the movement of 37 skin reflective markers over anatomical landmarks [5]. The ground reaction force (GRF) was recorded by a force plate (AMTI, Massachusetts, USA) collecting at 960 Hz. The knee joint kinematics was calculated by the convention suggested by Grood and Suntay [7]. The following discrete variables were calculated during the contact phase: peak vertical GRF, peak joint moment, joint angle at initial contact (IC), peak joint angle and range of motion, on three orthogonal planes respectively. The discrete variables of right knee from each trial were used for inter-trial reliability. The mean of five trials were used for inter-session reliability. ICC were used to examine inter-trial (ICC (3, k)) and inter-session (ICC (3, 1)) reliability of discrete variables [18]. The absolute measures of measurements error was accessed by standard error of measurement (SEM) and MDC. Statistical analysis was performed in SPSS 21 (SPSS Inc., Chicago, IL, USA).
Results: According to the ICC classifications (greater than 0.75 is excellent) of Fleiss [8], all the discrete variables were excellent in inter-trial reliability. For the knee kinematics, the inter-trial reliability was generally better than the inter-session reliability. The knee flexion angles had higher SEM and MDC than valgus and internal rotation angles. For knee kinetics and peak vertical GRF, the peak knee abduction moment had a larger MDC compared to other moment variables. The peak vertical GRF and the peak knee flexion moment showed an excellent rank correlation between sessions.

Discussion: In the present study, the results showed that inter-trial reliability is higher than the inter-session reliability. The possible sources of variability include skin marker placement, body position of the standing static calibration and task difficulty. Among all the discrete variables, peak vertical GRF got the higher value in reliability and rank correlation. It implies that vertical GRF is the most reliable and repeatable variables over time. However, the MDC of the peak vertical GRF is 89.7N, which is large for clinical practice. It implies a difference smaller than 89.7N cannot be regarded as a true difference between two sessions. The reliability of peak knee valgus angle and moment are of great interest because they have been suggested to be able to predict ACL injury [3]. Both of them achieved an excellent inter-trial reliability. The MDC of peak valgus angle and moment were 2.2 (39% of SD) and 23.1Nm (59% of SD). Although peak knee abduction moment had a high inter-session reliability, the peak knee valgus angle demonstrated a promising MDC with smaller percentage of SD.

Conclusion: Among all the discrete variables, the peak vertical ground reaction force is the most reliable variables. Although peak knee abduction moment had a high inter-session reliability, the peak knee valgus angle demonstrated a promising minimum detectable change with smaller percentage of standard deviation.

References:


A Clinical-friendly Motion Capture System to Evaluate Knee Instability in ACL-Deficient Patients

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Background
Knee instability related to ACL-deficiency (ACLD) is an important criterion for diagnosis and decision of return-to-sports (RTS). Currently, the assessments rely on subjective physical examinations, while objective measurements with conventional motion capture system (MCS) is not readily available in most sports clinics. OptiKnee is a compact MCS that enables collection of knee kinematic data. In this study, we use OptiKnee to compare knee kinematics in ACLD patients with healthy controls.

Materials and Methods
Ten unilateral ACLD patients and 10 healthy controls were recruited. Demographic data and IKDC scores were collected. All participants performed a standardized single-legged hop landing (SLHL) task on both legs. At least 5 trials were collected for each leg. Knee kinematics was obtained and changes at 250 ms after landing were examined. Comparisons were made between the injured and contralateral sides in ACLD subjects, and their side-to-side difference (SSD) were compared to the controls.

Results
ACLD limbs demonstrated a decrease in maximum knee flexion and an increase in internal rotation and adduction after landing in SLHL as compared to the contralateral limb; while no significant difference was detected between both limbs in the controls. Significant SSD in knee flexion and internal rotation was detected between ACLD patients and controls.

Discussion and conclusion
Our results demonstrated that OptiKnee was able to detect kinematic changes related to knee instability in ACLD patients. This clinical-friendly system may enable objective quantitative assessment of knee function and provide evidence for decision of RTS.
Quantitative Evaluation of Three-dimensional Dynamic Knee Laxity with Isolated Anteromedial- or Posterolateral-bundle Anterior Cruciate Ligament Deficient Knees

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Background: Anterior cruciate ligament (ACL) consists of the anteromedial bundle (AMB) and posterolateral bundle (PLB). The purpose of this study was to clarify how these bundles contribute to the knee joint stability during the Lachman test and the pivot shift test.

Materials & Methods: Twelve fresh-frozen hemi-pelvis lower limbs (6 paired) were used. Each bundle was determined arthroscopically and the AMB or PLB was cut first and subsequently the remained bundle was cut. The Lachman test and the pivot-shift test were performed under the following conditions: (1) ACL-intact (n=12), (2) AMB-cut/PLB-intact (n=6), (3) PLB-cut/AMB-intact (n=6), and (4) ACL-deficient (n=12). Each knee went through the conditions, either (1)-(2)-(4) or (1)-(3)-(4). The anterior tibial translation (TT) during the Lachman test and the acceleration of posterior tibial translation during the pivot-shift test (APT) were measured using an electromagnetic measurement system.

Results: The mean TT during the Lachman test in the ACL-deficient condition was significantly larger than those in other three conditions. No significant differences were observed among the conditions, (1), (2) and (3). The mean APT in the ACL-deficient condition was significantly larger than those in other three conditions. In addition, the mean APT was significantly increased in the PLB-cut (only AMB intact) condition compared with the ACL-intact group, whereas, no significant difference was observed between the AMB-cut (PLB intact) condition and the ACL-intact condition.

Discussion & Conclusions: These results suggested that both AMB and PLB contribute to the control of TT and PLB may play a more dominant role in the control of the pivot-shift phenomenon than AMB.
Altered three-dimensional knee kinematics during step and turn are associated with patient-reported outcomes following multiple-ligament knee reconstruction

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Background
Multiple-ligament knee injury is devastating to patient function and a challenge for the orthopaedic surgeon. Considering the important role the biomechanics of the knee may have for overall patient function and its known contribution to long-term joint degeneration, detailed knowledge of knee function following multiple-ligament reconstruction (MLKR) could provide an important adjunct to post-operative rehabilitation and management. However, the biomechanical function of MLKR knees remains largely unknown. Previous work by our group has identified altered knee kinematics in MLKR patients compared to healthy controls during level walking, although the ability of patients to negotiate a more challenging task, such as step descent with a turning movement, is yet to be examined. To address this gap in the current knowledge, the purpose of this study was to i) determine differences in knee kinematics during a step and turn task between MLKR knees and matched healthy controls and ii) establish the relationship between knee kinematics and IKDC score in patients that have undergone MLKR.

Materials & Methods
Gait analysis was performed on 21 patients that had undergone MLKR a minimum of 12months prior. A second group of healthy participants (N = 17) was matched for gender, as well as within ±10% of height, weight and age. Retroreflective markers were attached to anatomical landmarks of the feet, lower limbs and pelvis (Cleveland Clinic marker set), supplemented by marker clusters attached to the middle of the thighs and calves. Following familiarisation trials, volunteers were recorded with a high-speed optoelectronic camera system (200Hz, Motion Analysis Corp, USA) while descending from stairs onto the floor, leading with the reconstructed limb and stepping over the lead foot with the contralateral limb to land at 90° to the original direction of travel. Volunteers were instructed to land with their lead foot placed parallel to the direction of travel prior to contralateral toe-off from the step. Three-dimensional knee angles and foot progression angle at initial foot contact, as well as range of motion during weight acceptance from initial contact to contralateral foot contact were extracted from each of 10-12 trials. Patients were compared to their matched control using a single-case approach with unpaired Student t-tests, while partial least squares regression was used to associate knee kinematics with IKDC and KOOS scores within the MLKR group.

Results
A sample of 13 males and 8 females were recruited, with an average period from surgery to follow-up of 5.4yrs (IQR 2.2 – 9.8). The control group was successfully pair-matched, with no significant differences between MLKR and control groups for age at follow-up, height, weight or BMI. Injury patterns were also variable between patients, with an incidence of 12.5% and 6% for nerve injury and vascular injury respectively, as well as meniscal repair or meniscectomy (25%). In addition, more than half the sample suffered other injuries, including fractures of the lower limbs and pelvis.

The MLKR group exhibited significantly (p=0.001) increased external rotation and significantly (p=0.031) increased flexion of the knee at initial foot contact. During weight acceptance, MLKR patients displayed significantly (p=0.019) increased internal rotation, although no significant difference in knee range of motion in any plane were observed during the entire pivoting movement. When compared on a single-case basis, 65% of patients landed with significantly
greater knee flexion (P <0.05), increased varus (47%) or valgus (47%), or increased external tibial rotation (82%) at initial ground contact. Similar patterns were observed for knee range of motion during weight acceptance, with MLKR patients displaying significantly reduced flexion (59%), frontal motion (47%) and increased internal rotation (59%). Regression analysis revealed that step and turn kinematics (frontal angle at initial contact and frontal range of motion during weight acceptance) were significantly associated with IKDC score (R^2_pred = 0.83, P<0.01) in the MLKR group. The amount of valgus at initial foot contact was positively associated with improved scores, with patients landing with a varus knee returning poorer scores.

**Discussion**

The functional mechanics of the knee following MLKR remain largely unknown. The current study presents the first detailed insight into the knee kinematics during a strenuous task such as a step descent and turn. The results suggest that MLKR patients employ different knee kinematics during step descent to prepare for a pivoting action. Although MLKR patients landed with a more toe-out pattern compared to healthy controls, which may have explained differences in knee rotation, MLKR patients also displayed differences in frontal angle at initial contact and frontal range of motion during weight acceptance. The degree of knee valgus at initial contact was positively associated with IKDC and KOOS scores; however the mechanisms explaining this relationship remain unclear. These results suggest that frontal alignment over the short-medium term is important to patient-reported outcomes of MLKR. Future work will focus on understanding the pre-operative and peri-operative factors that determine knee functional patterns and outcome during ongoing management.

**Conclusion**

MLKR patients utilise a distinctly abnormal pattern of knee kinematics to perform a step descent and turn task which is associated with self-reported outcomes. These results highlight the importance of knee function during post-operative rehabilitation and as a marker of recovery throughout ongoing management of the condition.
Background: The tibial avulsion fracture of posterior cruciate ligament (PCL) is one of the special PCL injuries. Treatment of tibial PCL avulsion fractures by arthroscopic suture fixation is a successful technique to restore tibial avulsion injuries of the PCL with well-documented radiographic healing, good clinical outcomes, and low complication rates. We would like to evaluate the outcome of arthroscopic treatment of tibial avulsion fracture of posterior cruciate ligament (PCL), try to find a simple and reliable technique.

Material and Method: A total 21 arthroscopically treated cases of PCL tibial avulsion fracture were retrospectively evaluated. Two tibial tunnels were drilled from the medial tibial tuberosity to the medial and lateral border of the avulsed site using PCL guide. Double strands NO.5 polyester sutures were passed through the fracture fragment using a suture pierce, then the sutures ends were pulled out through the two tibial bone tunnels. Finally the avulsion fracture fragment was fixed by tying the sutures. The Lysholm score was determined as the evaluation criteria.

Results: The mean follow-up period was 20.6 months. All cases were followed up. The Lysholm score improved significantly from (48.54±4.65) preoperatively to (95.33±3.25) at follow-up. There were no complications.

Conclusions: Arthroscopic suture with two tibial tunnels technique is a simple, reliable, and microinvasive treatment to PCL tibial avulsion fracture.