Anteromedial opening wedge HTO for the PCL deficient varus arthritic knee
A Prospective Ten - Fifteen Year Study

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Introduction:
Treatment of the young patient with medial compartment arthritis and a PCL deficient knee is a complex problem. This study evaluates the efficacy and survival of the anteromedial opening wedge osteotomy for PCL deficient knees with medial and patellofemoral compartment degenerative changes.

Method:
Twenty two patients have undergone an anteromedial opening wedge high tibial osteotomy for the PCL deficient varus knee. Patients were evaluated prospectively pre-operatively and at one five, ten and fifteen years post surgery by visual analogue pain scores and patellofemoral pain scores, subjective IKDC, WOMAC and SF-36. Radiographic evaluation to determine correction in the coronal plane and the degree of slope increase was performed at one-year post surgery. Patients have been followed from 8-15 years – mean 12 years.

Results:
All patients reported and improvement in PCL instability. There was a significant improvement in visual analogue pain and patellofemoral pain scores, subjective IKDC, WOMAC and SF-36 and overall knee function at one five, ten and fifteen years. Two patients have been converted to a TKA at 9 & 11 years. The survival at 10 years is 95%.

Conclusion:
This technique shows encouraging mid to long term results for a complex problem with a 95% ten year survival and a significant and sustainable improvement in pain scores, WOMAC, IKDC & SF 36.
The Validity of the Classification for Lateral Hinge Fractures in Open Wedge High Tibial Osteotomy

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[Background] Open wedge high tibial osteotomy (OWHTO) for knee osteoarthritis has become an increasingly performed technique. However, various complications including lateral hinge fracture (LHF) have been reported. Takeuchi et al. classified LHFs into three anatomically based types, related to the proximal tibiofibular joint. Here, the objective of this study was to validate the efficacy of their classification. [Material] Patients treated with OWHTO using TomoFix between 2009 and 2012 were investigated. The knees were divided into non-fracture (59 knees) and LHF (15 knees) groups, and the LHF group was further divided into Takeuchi types I, II, and III (seven, two, and six knees, respectively). [Method] The Japanese Orthopaedic Association (JOA) score and range of knee flexion were assessed pre-operatively and one year after OWHTO. The details of postoperative course were reported in LHF group. [Results] Pre-operative characteristics (age, gender and body mass index) showed no significant difference between the two groups. The mean JOA score was significantly improved one year after operation regardless of the presence or absence of LHF (p < 0.005, p < 0.001, respectively). However, six of seven type I cases had no LHF-related complications; both type II cases had delayed union; and of six type III cases, two had delayed union with correction loss and one had overcorrection. [Discussion] These results suggest that Takeuchi type II and III LHFs are structurally unstable compared to type I. [Conclusion] Takeuchi classification can provide an indication of potential complications relating to bone union after OWHTO.
Clinical Outcome of a Novel Fixation System for Open-Wedge High Tibial Osteotomy: Comparison with TomoFix

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Background: We have developed a novel fixation system (TriS Medial HTO Plate System; Olympus Terumo Biomaterials, Japan) for medial open-wedge high tibial osteotomy (OWHTO). The purpose of this study was to compare implant position and clinical outcome of the TriS and TomoFix (DepuySynthes, Switzerland) plates in OWHTO.

Methods: 46 patients (48 knees) who underwent OWHTO with a locking plate were enrolled in this study. Inclusion criteria involved patients who had medial osteoarthritis or spontaneous osteonecrosis of the knee. There were 30 women and 16 men with a mean age of 61 (51-68) years at the time of surgery. In the first 33 knees, the TomoFix was fixed to the tibia between 2010 and 2013 (Group F). In the remaining 15 knees, the TriS was fixed between 2014 and 2015 (Group S). In surgical procedure, we performed a biplanar osteotomy of the tibia. Beta-TCP spacer was implanted in the opening space. Then, a locking plate was implanted onto the tibia. All patients underwent clinical, radiological, and CT examinations before surgery and at 12 months after surgery. Concerning CT evaluation, a posterior reference line (PL) was drawn tangent to the posterior contour of the medial and lateral cortex on the axial view of the proximal tibia. The anteroposterior length of the proximal tibia (AP1) and the distance between the anterior edge of the tibia to the center of the proximal plate (AP2) were measured perpendicular to the PL. The plate position was defined with the %AP2/AP1. For each proximal-posterior screw, the screw angle was defined as the angle between the screw axis and the PL on the axial view of the tibia. The distance from the proximal-posterior screw axis to the center of the popliteal artery was measured perpendicular to the proximal-posterior screw axis.

Results: There was no significant difference in the background of the 2 groups. Postoperatively,
the knee score significantly improved in each group. Concerning the post-operative knee alignment and clinical outcome, there was no statistical difference in each parameter between the 2 groups. CT examination showed that there was a significant difference (p=0.01) in the plate position between Groups S (28%) and F (17%). The screw angle was significantly lower (p=0.02) in Group S (18°) than in Group F (27°). The distance from the screw to the popliteal artery was significantly shorter (p=0.01) in Group F (14mm) than in Group S (19mm).

Discussion: In both plate systems, the medial knee pain had resolved in all cases. The Tris plate was posteriorly fixed at the proximal tibia. The Tris screw was also inserted more parallel to the posterior cortex of the tibia. Previous studies reported that application of the plate in a more posterior position provides greater stability. The use of the TriS plate system provides better stability with its optimal placement and rigid fixation. The position of the proximal screw affects not only the stability of the osteotomy site but also safety during surgery.

Conclusion: This study demonstrates that the TriS plate produces superior stability and safety for bony fixation in medial open-wedge HTO procedures.
Open wedge high tibial osteotomy using three-dimensional printing model: Experimental analysis using porcine bone

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The purpose of this study was to evaluate the usefulness of a three-dimensional (3D) printing model for open wedge high tibial osteotomy (HTO) in patients with medial knee osteoarthritis. Computed tomography (CT) images were obtained from 10 extended porcine knees and 3D imaging was planned using the 3D-Slicer program. The osteotomy line was drawn from the predicted medial osteotomy site (approximately 3 cm below the medial tibial plateau) to the hinge point, the proximal end of the fibular head. After the osteotomy, the osteotomy gap was opened until the mechanical axis line connecting the hip and ankle joint centers was 62.5% from the medial border along the longest medial-to-lateral width of the tibial plateau maintaining the posterior tibial slope angle. The wedge-shaped 3D printing model was designed with the measured angle and osteotomy section and was produced by the 3D printer. The open wedge HTO surgery was reproduced in porcine bone using the 3D printing model and the osteotomy site was fixed with a plate. Accuracy of osteotomy and posterior tibial slope was evaluated after the osteotomy. The mean mechanical axis line on the tibial plateau was 61.8 ± 1.5% from the medial tibia. There was no statistically significant difference (p = 0.160). The planned and post-osteotomy correction wedge angles were 11.5 ± 3.2° and 11.4 ± 3.3°, and the posterior tibial slope angle was 11.2 ± 2.2° pre-osteotomy and 11.4 ± 2.5° post-osteotomy. There were no statistically significant differences (p = 0.854 and p = 0.429, respectively). This study could obtain good results of high tibial osteotomy using
3D printing model in porcine legs. Therefore, this method can be applied later to open wedge high tibial osteotomy clinically in human.
Advantages of computer-assisted navigation system in open-wedge high tibial osteotomy

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**Background:** It has been reported that posterior tibial slope (PTS) tends to increase following open-wedge high tibial osteotomy (OWHTO). The present study investigated the usefulness of the navigation system in control of PTS in OWHTO.

**Methods:** Sixteen knees in 16 patients who underwent OWHTO using a navigation system for medial knee osteoarthritis (OA) were examined (Group NS). The amount of the change of PTS (°) on the navigation system was recorded at the time of surgery in each patient. The PTS change was also measured by pre- and postoperative digital radiographs. The angle change was expressed as a positive values regardless of decrease or increase in the slope to evaluate the amount of the change. The PTS changes on the navigation system and on the radiographs were compared to assess the validity of the navigation system. Twenty-eight knees in 28 patients who underwent OWHTO without using the navigation system were also examined (Group non-NS). The PTS changes in Group non-NS were compared with those in Group NS on radiographs.

**Results:** In Group NS, PTS increased in 10 knees and decreased in 5 knees on the radiographic evaluation. In Group NS, PTS increased in 15 knees and decreased in 9 knees and did not change (less than 0.5° change) in 3 knees. In Group NS, the mean PTS change was 2.4 ± 1.4° on the navigation system and 2.38 ± 1.20° on radiographs. There was no statistically significant difference between the mean values on the navigation system and the radiographs. The mean difference in the PTS change between on the navigation system and on radiographs was 0.38 ± 0.50°. There was a strong correlation between the measurement value on the navigation system and the value on radiographs (R = 0.97). The mean change of the PTS in Group non-NS was 1.59 ± 4.21°. There was no statistically significant difference in the PTS change on radiographs between Group NS and Group non-NS. However, 10 knees (36%) in Group non-NS showed a change of greater than 4° while none of the knees in Group NS showed a change of greater than 4°.

**Discussion:** The measurement values of PTS change obtained by the navigation system strongly correlated with the radiographic measurement. In addition, the mean difference between the two measurement systems was less than 0.5°. These results suggest that the navigation system is reliable to control PTS during surgery at least if plain radiographs are used to evaluate the PTS change. The PTS often changed greater than 4° when OWHTO was performed without using the navigation system. In contrast, the PTS changes were below 4° in all the knees when OWHTO was performed using the navigation system, suggesting that the navigation system is useful to control PTS and reduce a large error of the PTS change during OWHTO.

**Conclusions:** Our results suggested that navigation system is useful to accurately perform OWHTO by monitoring the change of PTS during surgery.
Survival and clinical outcomes of high tibial osteotomy for medial knee osteoarthritis

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Background

Medial opening wedge high tibial osteotomy (MOWHTO) has been used successfully in the past to treat medial compartment osteoarthritis. Most previous studies however have reported on the variable survival rates with little documented on the pain relief of the procedure; one of the primary indications for doing a MOWHTO. However most previous studies have mainly reported on survival rates of the procedure which have been variable. Very little has been reported on pain relief following the procedure, although it is a primary outcome of a MOWHTO. Therefore the aims of this study were to i) Describe the patient demographics and surgical outcomes, including complications, of a case series of medial opening wedge HTOs for treatment of medial knee OA; ii) Determine the procedure survivorship up to 10 years post-surgery and iii) Identify patient and surgery-related factors associated with pain relief following MOWHTO.

Materials & Methods

A cohort of medial opening wedge osteotomies (MOWHTOs) performed for the treatment of medial compartment knee osteoarthritis was extracted from a clinical research database. Patients underwent MOWHTO under tourniquet control, fixated internally and bone grafted. Concomitant procedures were performed where required (ACL, PCL reconstruction; meniscal or cartilage treatment). Patient demographics were extracted from the clinical research database and complications were identified by detailed review of clinical notes. The cohort list was submitted to the Australian Joint Replacement Registry to verify cases converted to total knee replacement (failures) and deceased patients. Survival analysis was conducted using right-censored data with Kaplan-Meier analysis. A normal distribution was fitted to the survival data and estimates of average and maximum survival were calculated. Pain relief was defined as the change in KOOS-Pain subscale between pre-operative and post-operative assessments. A partial least squares regression model was fitted with pain relief as the response variable and patient demographics, concomitant procedures and post-operative limb alignment as predictors.

Results

The patient cohort (N = 211) was predominantly male (84%) with a median age of 51yrs (IQR 44 – 55yrs) and median BMI of 28.9 kg/m² (IQR 26 – 32 kg/m²). In addition, 14.8% of patients indicated that they had smoked regularly at some point in their lives and 5.4% were treated through workers compensation. The patients were administered the KOOS questionnaire at a median follow up period post-operatively of 2.1 years (IQR 1.1-3.5yrs). At the latest post-operative follow-up, significant (P<0.01) improvements were observed for all KOOS sub-scales, however none returned to the level of age-matched normative scores. Complications requiring medical or surgical intervention (superficial infection; delayed union; deep vein thrombosis and adverse medication reaction) were documented in 8 patients (3.9%). A total of 13 conversions to total knee replacement (6.3%) occurred. Median time to failure was 7.7 years (IQR 5.4-8.6). Kaplan-Meier analysis revealed 97.7% survival at 5yrs (95%CI 95 – 100%) and 80% at 10years (95%CI 69-92%). Parametric analysis allowed for extrapolation of the survival curve and indicated that the estimated mean time to failure was 12.5yrs (95%CI 10.5-14.6yrs) and few would be expected to survive past 21 years (99th percentile 20.6yrs; 95% CI 15.7-25.6yrs). The model of pain relief was significant (P < 0.01) and provided a reasonable fit (R² = 57%). The period between surgery and the KOOS
follow-up was most associated with poorer pain relief compared to the sample average (standardized β = -0.36), followed by the KOOS-Pain score recorded preoperatively (standardized β = -0.32) and male gender (standardized β = -0.21). Factors associated with higher pain relief included increased post-operative valgus (standardized β = 0.21), increased pre-operative BMI (standardized β = 0.21) and whether concomitant cartilage treatment was performed (standardized β = 0.21).

Discussion
The purpose of this paper was to describe the demographics, procedure survival and pain relief of patients undergoing MOWHTO for the treatment of medial compartment knee osteoarthritis. Survival rates at 5 and 10yrs follow-up are consistent with previous reports, however this is the first study to estimate projected average and maximum survival and provides important guidance to surgeons counselling patients contemplating the procedure for the indication described. The low complication rate and significant improvement in KOOS scores suggests that MOWHTO is a safe and effective procedure for treatment of significant medial knee osteoarthritis that has a finite longevity. The present study is the first to investigate pain relief in this patient population and the results suggests that increased frontal correction, increased BMI and concomitant cartilage treatment afford greater pain relief in the sample studied. Whether this coincides with improved survival remains to be seen and future work should be directed toward improving patient selection for this procedure.

Conclusion
MOWHTO is a relatively safe procedure with excellent 5 year survivorship in patients with predominantly medial compartment knee osteoarthritis. Surgeons contemplating the procedure for this indication can counsel patients that the average longevity is 12.5years and the maximum may be as high as 21yrs. Furthermore, patients that present with increased post operative valgus, higher BMI and receive a concomitant cartilage procedure can be expected to report above-average pain relief.
Medial Gap Technique: New Surgical Concept for Quantitative and Safer Soft Tissue Balancing in Posterior-stabilized TKA

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Background:

Although gap balancing technique has been reported to be beneficial for the intra-operative soft tissue balancing in posterior-stabilized (PS)-TKA, excessive release of medial structures for achieving perfect ligament balance would be more likely to result in medial instability, which would deteriorate post-operative clinical result with persistent pain [1].

We have devised a new surgical concept; named as “medial gap technique” aiming at medial stability with permitting lateral looseness. With the quantitative soft tissue balance measurement using newly developed offset type tensor [2], we modified conventional gap balancing technique to provide quantitative and safer intra-operative soft tissue balancing with avoiding medial instability.

In this study, we compared intra-operative soft tissue balance between medial gap technique (MGT) and measured resection technique (MRT) in PS-TKA.

Material:

The subjects were 256 patients with varus type osteoarthritic knees, underwent primary PS-TKAs. The surgical techniques were MGT in 112 patients (96 female, 16 male) and MRT in 144 patients (118 female, 26 male). There were no significant differences between two groups in the pre-operative clinical features including age, sex, ROM and deformity.

Method:

A distal femoral and a proximal tibial osteotomy were performed perpendicular to the mechanical axis. Ligament imbalance in the coronal plane was corrected by medial soft tissue release, which should be carefully performed not to be excessive until a spacer block corresponding to resected bone thickness from lateral tibial plateau could be inserted at extension. The residual lateral laxity was permitted. Following extension gap preparation, a varus angle (°) and joint center gap (mm) at the knee extension and 90° of flexion were measured using an offset type tensor with applying 40 lbs. (177.9N) of joint distraction force.

As for the flexion gap preparation, in the MGT group, the level of femoral posterior condylar osteotomy was determined based on the difference of joint center gap between extension and flexion, and femoral rotation angle were based on the varus angle difference.

Intra-operative joint gap kinematics was measured with femoral trial in place and patello-femoral (PF) joint reduced [2]. We measured varus angle and joint component gap at 8 different knee flexion angles; 0°, 10°, 30°, 45°, 60°, 90°, 120°, and 135°. From these component gaps and varus angles, we calculated a medial compartment gap (MCG) and a lateral compartment
gap (LCG) by using a trigonometric function. Also we calculate the increase of both compartment
gaps from those at full extension, named as joint gap loosening (mm). Both compartment gaps and
joint gap loosening were compared between 2 groups using unpaired t-test, and the difference
between medial and lateral gaps in each group were compared using paired t-test (p <0.05).

Results:
The mean MCG with the knee at 0°, 10°, 30°, 45°, 60°, 90°, 120° and 135° were 10.9, 13.3, 14.0,
13.8, 13.9, 14.1, 13.7 and 12.5 mm respectively in MGT group and 10.3, 13.0, 14.0, 14.2, 14.6, 15.3,
14.1, and 12.2 mm respectively in MRT group. The mean LCG at 8 different flexion angles were
respectively 12.7, 15.7, 17.1, 17.2, 17.5, 17.7, 17.4 and 15.4 mm in MGT group and 12.0, 15.2, 16.8,
17.4, 17.9, 18.8, 18.0 and 15.8 mm in MRT group. In both groups, LCG showed significantly larger
values than MCG at all flexion angles, and both LCG and MCG showed the largest values at 90° of
knee flexion. Both medial and lateral joint gap loosening were significantly lower in MGT group
than MRT group at 30° to 120° for medial, and 45° to 135° for lateral joint loosening.

Discussion:
In the present study, we found the stability at the medial compartment were significantly higher
than the lateral throughout range of motion in both groups. The lateral looseness was
physiologically observed in normal knee [3] and also important for post-operative knee flexion after
TKA [4]. In MGT, we quantitatively measured intra-operative soft tissue balance, and calculated the
appropriate resection thicknesses from posterior femoral condyles. Therefore, joint gap loosening
with knee flexion were significantly smaller in MGT group than MRT group. This would be
beneficial for the post-operative knee stability.

We have found the higher joint distraction force resulted in the higher varus imbalance during
tensor measurement [5]. This phenomenon would be caused by the stiffness difference between
medial and lateral soft tissues. This would be a reason why gap balancing technique was difficult to
be performed quantitatively and safely by many surgeons. We also found the difference in varus
angle between extension and flexion would not differ with different joint distraction force between
20 to 60 lbs. Therefore, we used this difference to determine the external rotation angle of femoral
component, and the less joint gap loosening with knee flexion in both medial and lateral
compartment were observed in MGT group.

Conclusion:
We introduced a new surgical concept named “medial gap technique (MGT)” aiming at medial
stability and safer soft tissue balancing in PS-TKA. We have found MGT was effective for
intra-operative soft tissue balancing to be quantitative, consistent and safer.

References:
1. Liebs TR, Kloos SA, Herzberg W, et al. The significance of an asymmetric extension gap
on routine radiographs after total knee replacement: A new sign and its clinical significance.


Clinical and Radiological Results of Double Level Osteotomy for Varus Knee Osteoarthritis. Review of Our Experiences

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Introduction:
Osteotomies around the knee is generally indicated for patients with high activity level who have uni-compartmental knee osteoarthritis because total knee arthroplasty in this patient population may not be a good option. In addition, recent progresses in surgical procedure such as bi-plane osteotomy and use of rigid fixation device (LCP) and bone substitute materials (β-TCP) have facilitated early functional recovery and expanded the indication for osteotomy. In Japan, we frequently encounter osteoarthritic patients with severe varus knee deformity requiring surgical treatment. We have indicated and performed double level osteotomy (DLO) in such situation. The concept of DLO was to obtain anatomical knee joint-line by bi-plane cut closed wedge distal femur osteotomy (DFO) and bi-plane cut open wedge high tibial osteotomy (HTO) with the use of LCP and β-TCP. The purpose of the study was to examine clinical and radiological outcomes of this procedure in our practice.

Patients & Methods:
Fourteen knees in 13 patients with severe varus knee deformity who underwent DLO and could be followed up for clinical and radiological assessments were included in the study. DLO was indicated for medial compartment osteoarthritic knees with severe varus malalignment. Surgical goal of DLO is to reconstruct the anatomical knee joint line while correcting the varus malalignment. Whole leg weight-bearing radiographs at the preoperative period and 6 months after surgery were available for 10 patients. Radiological parameters measured for analysis were as follows: mechanical tibiofemoral angle (mTFA), mechanical lateral distal femoral angle (mLDFA), medial proximal tibia angle (MPTA), and joint-line convergence angle (JLCA). In addition, pre- and postoperative clinical outcomes were evaluated using the KOOS and the IKDC score.

Results: Each of the radiological parameters improved after surgery. The postoperative changes in measured values for mTFA, MPTA, mLDFA, and JLCA from the preoperative to the 6-month evaluation were -14.1° to 1.6°, 82.4° to 91.2°, 91.2° to 85.1° and 6.0° to 4.5° respectively. KOOS and IKDC scores also improved after surgery from 130 to 349 and 35 to 55, respectively.

Discussion:
This study showed that DLO for patients with severe varus malalignment and medial compartment osteoarthritis could accomplish satisfactory clinical outcomes by normalizing coronal alignment while avoiding joint line obliquity.
Outcomes of distal femoral varus osteotomy in patients with valgus knee osteoarthritis

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Background: Treatments of valgus knee osteoarthritis (OA) in young patients are challenging. Distal femoral varus osteotomy (DFVO) is a surgical method to reduce the mechanical load on the lateral compartment of the knee shifting the laterally-shifted weight bearing line medially. The purpose of this study was to investigate the outcome of DFVO in young and middle-aged patients with valgus knee OA.

Material and Methods: Seven knees in 7 patients (4 males and 3 females) who underwent DFVO (distal femoral varus closing-wedge osteotomy) in our hospital for valgus knee OA were retrospectively examined. Abrasion arthroplasty was performed in 5 patients and osteochondral autograft transplantation was performed in 1 patient as a combined surgery. The mean age at the time of surgery was 40.6 ± 4.5 years old (ranging: 28 - 55). The mean follow-up was 22.4 ± 5.2 months. Radiographically, hip-knee-ankle (HKA) angle, weight bearing line (set the most medial point of the proximal tibia as 0% and most lateral point as 100%), mechanical lateral distal femoral angle (mLDFA), the lateral joint space distance in the Rosenberg view were assessed preoperatively and at final follow-up. Clinical outcomes were evaluated with the Knee Injury and Osteoarthritis Outcome Score (KOOS) preoperatively and at final follow-up. Second-look arthroscopy was performed at the time of the plate removal in 5 patients.

Results: The mean HKA angle was changed from 4.9 ± 1.3° valgus preoperatively to 7 ± 1.0° varus postoperatively. The mean mechanical axis was from shifted 76.3 ± 6.6 % to 22.3 ± 3.8 % and the mean mLDFA was changed from 83.7 ± 1.5° to 94.3 ± 0.6°. The mean lateral joint space distance in the Rosenberg view was significantly increased from 0.1 ± 0.2 mm to 2.4 ± 2.0 mm. (p <0.05). The preoperative mean KOOS subscale scores were: pain 42.1 ± 22.5; symptoms 42.9 ± 27.9; activities of daily living (ADL) 62.4 ± 21.0; sport and recreation function (Sport/Rec) 30.7 ± 24.5 and knee-related quality of life (QOL) 34.8 ± 16.5. The mean subscale scores at final follow-up were: pain 75.4 ± 16.2; symptoms 65.3 ± 18.7; ADL 84.7 ± 12.0; Sport/Rec 47.1 ± 27.1 and knee-related QOL 52.7 ± 23.6. The pain and ADL scores were significantly improved postoperatively (p < 0.05). A well-coverage with fibrous cartilage over the lateral femoral and tibial condyle was observed in all 5 patients at second-look arthroscopy. In 1 patient who received osteochondral autograft transplantation combined with DFVO, manipulation was required.

Discussion: Overall favorable clinical outcomes were obtained in most of the patients after DFVO in the short-term follow-up. In addition, an improvement of the lateral compartment of the knee with regenerated fibrous cartilage was observed.

Conclusions: The present study suggests that DFVO can be a treatment option for young and middle-aged patients with valgus knee OA.
**An Open-wedge Osteotomy of the Proximal Tibia with Hemicallotasis**

–Technique and Outcome –

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**Background:** High tibial osteotomy is a well-established procedure for osteoarthritis of the medial compartment of the knee with a varus deformity. Either a closed-wedge osteotomy or a dome osteotomy has been widely conducted while, during the last two decades, medial opening-wedge osteotomy has gained popularity. Among the procedures of proximal tibial open-wedge osteotomy, "hemicallotasis (HCO)" has been first described by Turi G. et al. as a new technique with an external fixator using a gradual distraction. The purpose of this study is to conduct a prospective more than 10-year follow-up trial of the patients who underwent HCO for medial osteoarthritis of the knee.

**Patients & Methods:** Between 1995 and 2000, 37 knees of 33 patients underwent HCO for severe medial compartment osteoarthritis of the knee. Among them, 29 patients with unilateral HCO were enrolled in this study. The average age of the patients at surgery was 65 years-old (range 52 to 74). We performed a prospective follow-up of these patients. All patients were evaluated before surgery and at three postoperative time points; the first follow-up at the short-term (1-4 years), the second at the middle-term (5-9 years), and the final at the long-term more than 10 years. At each evaluation, we used the Hospital for Special Surgery (HSS) scoring system for clinical examination and measured the femoro-tibial angle (FTA) in a standing anteroposterior view and the tibial inclination angle (IA) in the lateral view for radiological examination. Failure was defined as the need for conversion to a total knee arthroplasty (TKA) and an HSS score < 70 points. In addition, other 20 patients with unilateral HCO were performed three-dimensional quantitative gait analysis to evaluate the dynamic effect of HCO on gait before and one year after the surgery.

**Results:** Twenty-eight, 23 and 19 patients were available for review at the short-term(mean:2.5 years), mid-term(mean:7.1 years) and long-term(mean:14.2 years) follow-up examinations, due to failure, removal, disease or death.

[Conversion to TKA] Only one patient required conversion to total knee arthroplasty during the entire follow-up period.

[Clinical assessment] Among the 19 patients available for the long-term follow-up review, the mean Hospital for Special Surgery knee score was 60 preoperatively, increasing to 92, 90 and 85 at each follow-up period (respectively, p<0.001;paired t-test), with no cases of failure(score<70).

[Radiological assessment] The mean preoperative FTA was 181.5° (SD 3.2°, range 176° to 191°). The mean postoperative FTAs were 167.3° (SD 1.3°, range 164° to 170°) at the short-term, 168.0° (SD 1.6°, range 164° to 170°) at the mid-term, and 169.6° (SD 3.2°, range 166° to 180°) at the...
long-term follow-up. The FTAs at the mid- and long-term follow-up showed no significant difference from those at the short-term. There were no significant post-operative changes in the IA. For gait analysis, all patients showed the decrease in knee adduction moment during gait.

**Discussion:** HCO has some attractive advantages including simpler technique, immediate postoperative weight-bearing and muscle exercise. Furthermore, distraction osteogenesis in HCO allows small corrections to be made in order to achieve the desired correction in the coronal plane. The fixator can maintain the corrected position until union occurs. The ability to maintain the sagittal alignment, which is difficult to control after stapling or various forms of plating, is an advantage of HCO. The outcomes in the conventional high tibial osteotomies are known to deteriorate over time. However, it is known that the acquisition and maintenance of proper postoperative valgus alignment can provide durable and satisfactory long-term results. Our results suggest that HCO can decrease the decrease medial compartment load during gait postoperatively and maintain the optimal correction angle with lasting long time. These also may explain a satisfactory long-term outcome seen in the present study. There are some limitations to our study. The number of patients involved was small. This study should be supported by the outcomes with long-term follow-up in a much larger group of patients.

**Conclusion:** Our results suggest that HCO can decrease the dynamic loading on the medial compartment of the knee and maintain the acquired coronal correction angle without alteration of the IA at long-term follow up, thus providing a good long-term clinical outcome.
Are Factors Considered for Deciding Whether to Perform High Tibial Osteotomy or Unicompartmental Knee Arthroplasty Same?

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Background
As demographics and lifestyle are changing, the number of patients with medial unicompartmental knee osteoarthritis (OA) requiring surgical intervention is steadily increasing. Although the surgical principle for each procedure is fundamentally different, namely realignment versus resurfacing, both high tibial osteotomy (HTO) and unicompartmental knee arthroplasty (UKA) can be viable treatment options in this clinical scenario. Traditionally, HTO is indicated for young patients with high physical demand who has mild OA with varus deformity. On the contrary, elderly patients with low demand who has severe OA with minimum varus deformity were ideally indicated for UKA. However, recent advances in surgical techniques, instrumentation systems, and implant design of both procedures have subsequently improved clinical outcomes and longevities, and expand the indication for both procedures. Therefore, most indications have been shared and multiple recent literatures report comparable clinical outcomes after HTO and UKA in patients who had medial unicompartmental knee OA. However, there is a paucity of data regarding factors associated with patient satisfaction after HTO and UKA. We sought to determine demographic factors affecting patient satisfaction following HTO and UKA.

Material
We retrospectively reviewed the medical records and radiographs of 67 UKAs and 53 medial open wedge (OW) HTOs with minimum follow-up time of one year. We included only patients who had satisfactory postoperative alignment (50% < weight loading line; WLL < 75%). Finally, 67 UKA and 44 HTO were enrolled in this study.

Methods
Patient demographics (age, height, weight, BMI), preoperative varus deformity (mechanical femoro-tibial angle; mFTA), OA degree (Ahlbäck grade) were recorded. At postoperative 1 year follow-up, pain VAS, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and patient satisfaction (New Knee Society Score; KSS) were assessed. We classified patients into 3 groups (satisfied, neutral or dissatisfied) or 2 groups (satisfied or dissatisfied) based on the satisfaction scores of new KSS. Variables with p < 0.1 on univariate analysis were used for multivariate regression analysis to identify risk factors for dissatisfaction.

Results
In UKA group, higher patient satisfaction was associated with older age (satisfied patient 21% in < 60 Y vs. 79% in ≥ 60 Y, p = 0.011) and lower mFTA (satisfied patient 85% in < 5° vs. 15% in ≥ 5°, p = 0.007). In HTO group, patients dissatisfaction was related to severe OA (9 of 10 patients (90%) who had Ahlbäck grade ≥2 were dissatisfied, p <0.01). In addition, UKA showed superior satisfaction compared with HTO in patients with ≥ 60 Y (30 in UKA vs. 23 in HTO, p <0.001) and < 5°mFTA (29 in UKA vs. 24 in HTO, p = 0.02), and Ahlbäck grade ≥ 2 (28 in UKA vs. 16 in HTO, p < 0.01).

Discussion and Conclusion
Older age and lesser varus deformity were associated with higher patient satisfaction following UKA and severe OA was identified as a risk for dissatisfaction after HTO. Surgeon should be aware that factors associated with patients satisfaction following HTO and UKA might be different and age, varus deformity and OA severity should be considered when deciding whether to perform HTO or UKA.
Analysis of the tibial osteotomy thickness of unicompartmental knee arthroplasty

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Abstract

Background: Satisfactory outcomes have already been reported for both total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA), however, there is still no report talking about the tibial osteotomy thickness. Thus, the purpose of this study is to compare the tibial osteotomy thickness of UKA and TKA in patients of medial compartment osteoarthritis.

Materials & Methods: From January 2013 to June 2015, 33 patients (35 knees) with medial compartment osteoarthritis were enrolled in this study. There were 14 males (15 knees) and 19 females (20 knees). The ages of patients ranged from 43~79 years (average 62.2 years). All the patients suffered from medial tenderness, weight-bearing pain, and stenosis of the medial compartment. We analyzed the X-ray preoperatively to estimate the osteotomy level, position, and thickness of the medial tibial plateau according to preoperative TKA template. Then an unicompartmental knee arthroplasty (UKA) was performed. Meanwhile, we measured the actual osteotomy level position, and thickness after UKA.

Results: X-ray film was taken after surgery, and compared with the preoperative one, and the corresponding data were recorded. According to preoperative measurement, the average expected medial tibial osteotomy thickness of TKA was 1.85mm (1mm-2.5mm), and that of UKA was 4.32mm (3.2mm-5.6mm). While, according to the postoperative measurement, the average actual medial tibial osteotomy thickness of UKA was 7.22mm(3.0mm-9.7mm). Significant difference was found among these three groups( P<0.05).

Discussions & Conclusions: There are still very large differences between TKA and UKA in the respect of tibial osteotomy thickness, which is significant in preserving medial bone mass and late revision.

Key words unicompartmental knee arthroplasty(UKA), tibial osteotomy thickness
Postoperative Flexion Balance is improved after TKA by Modified Gap Technique with Imageless Navigation

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a) Background
A goal of total knee arthroplasty (TKA) is to obtain symmetrically balanced extension and flexion gaps. To balance the gaps during surgical procedure, two surgical techniques are commonly used. One is measured resection technique (MRT), and the other is gap balancing technique (GBT). Imageless navigation assisted TKA is originally based on MRT in which bony landmarks are used to determine proper component placement. In this technique all bone cutting was underwent with the assistance of the navigation and soft tissue balancing was subsequently carried out to make rectangular shaped gap. Although imageless navigation is known to be useful to accurately reconstruct the mechanical axis of the lower limb, there are some cases in which gap balancing between extension and flexion is difficult after the bone cutting. GBT is reported to offer superior reliability in obtaining proper flexion and extension gap compared to MRT. To obtain both correct mechanical alignment and more well-balanced gap, we have started modified GBT (MGB) TKA with the assistance of imageless navigation since 2013. Therefore, the purpose of this paper is to characterize our current operative technique and to clarify effectiveness of this method to achieve well-balanced gap.

b) Surgical technique
The Stryker imageless navigation system (Precision version 4.0), which do not need intraoperative fluoroscopy or preoperative CT images, is used for computer-assisted implantation. Following a conventional medial midvastus approach, bony landmarks such as Whiteside line, epicondylar axis and tibia AP axis are registered into the computer navigation. Firstly, distal femoral cut and proximal tibial cut are made perpendicular to the mechanical axis with extramedullary cutting blocks positioned under navigation guidance. The created extension gap is evaluated with a spacer block and soft tissue release or osteophyte resection is performed to obtain the rectangular extension space. Once the rectangular extension gap is created, the extension and flexion gaps are measured at full extension and at 90 degree flexion of the knee by applying 40N torque to the tensioner. Then the difference of the two gaps (extension gap – flexion gap) is calculated and the necessary thickness of posterior condyle bone resection is estimated. The femoral anterior/posterior and chamfer cutting block (4 in one femoral cutting block) is positioned by monitoring on the navigation screen. The navigation system offers real-time feedback of femoral rotation, the risk of anterior femoral notch and the thickness of posterior femoral bone resections. To obtain equal extension and flexion gaps, the position of the femoral cutting block is adjusted to the estimated necessary bone resection value as well as controlling femoral rotation and anterior femoral notch risk. When the flexion gap before bone resection is trapezoidal, femoral rotation is adjusted to maximum 1 degree external or internal from the neutral position on the navigation.

c) Method
From April 2012 to March 2015, total 144 knees were replaced using imageless navigation. Femoral rotation and flexion gap was determined by conventional MRT between April 2012 and March 2013. Between April 2013 and March 2015, the navigation assisted MGB was utilized. Inclusion criteria in this study is varus osteoarthritis knees and CR type TKA. Twenty-three knees by MRT and 39 knees by MGB were enrolled. Pre-operative variables were recorded, including age, sex, body mass index, frontal alignment, and range of motion. Axial radiograph of the distal femur was taken by the method of Kanekasu et al at 3 months after operation and the flexion soft tissue balance was evaluated. Lift off angle (LOA) of femoral component, which was the angle between tibial cutting line and posterior condylar axis (PCA), was measured on the axial radiograph. The number of outlier of a LOA, which was defined as a deviation >3 degree of the varus or valgus, was compared in both group. Post-operative LOA and outlier of LOA were compared in both group using student t-test.

d) Result
There was no statistically significant difference in terms of demographic characteristics between MRT group and MGB group. Mean post-operative LOA was 2.3±2.7 degree varus in MRT group and 1.2±1.7 degree varus in MGB group (p<0.05). Mean post-operative LOA in MGB group was significantly lower than in MRT group. In other words, flexion balance in MGB group was significantly more rectangular than in MRT group. Outlier in MRT group were 7 cases (30.4%) and in MGB group were 3 cases (7.7%). Outlier decreased significantly in MGB group (p<0.05).

e) Conclusion
The surgical technique by MGB with the assistance of the imageless navigation was shown in detail. In terms of flexion balancing, there was statistically significant improvement in the MGB group compared to MRT group at postoperative axial X-ray of the distal femur. Also there were less outlier more than 3 degree in MGB than MRT. Navigation assisted MGB would improve soft tissue balancing than conventional navigation assisted TKA.
The effect of total knee arthroplasty on active knee extension during treadmill walking

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Background

Fixed flexion contracture of the knee due to osteoarthritis is common in patients requiring a total knee arthroplasty (TKA). An inability to fully extend the knee is detrimental to overall knee function and increases energy expenditure during walking. Individuals may consciously limit extension during walking to minimize pain in the patellofemoral or tibiofemoral joints, avoid discomfort due to joint stiffness, or minimize joint instability. TKA is a well-established procedure for restoring extension to knees affected by fixed flexion contracture with residual post-operative contracture resolving in 2-3yrs. However, there is a suspicion that despite receiving a knee capable of achieving full extension, patients did not utilise this capability post-operatively. To address this gap in the current knowledge, the purpose of this study was to determine whether patients who receive full extension following a Total Knee Arthroplasty (TKA) at the end of the surgical procedure use the full range of motion achieved intraoperatively when they commence pain-free walking post-operatively.

Materials & Methods:
Gait analysis of 24 patients undergoing unilateral TKR was conducted prior to surgery and repeated when they commenced pain-free locomotion. On attendance for gait analysis, 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, a high-speed optoelectronic camera system (200Hz, Vicon Bonita/Nexus, USA) was used to record maximum knee extension of the operated limb during standing and while prone (passive knee extension), step-descent onto the injured limb from a 20cm high step, as well as treadmill walking at both a self-selected comfortable speed and 130% of that speed for one minute each. Student t-tests were used to compare differences between pre-operative and post-operative values in the prone and standing trials. Two-way repeated-measures ANOVAs were conducted on the minimum flexion angle in the step-down and walking tasks, to determine if there were any differences over time, as well as any interaction between task and time.

Results:
A sample of 6 males and 15 females were recruited, with an average period from surgery to follow-up of 4.6 ± 0.5 months. Intra-operative computer navigation results confirmed successful restoration of extension as a result of the TKR (post-operative median 0, IQR, -0.5 – 0.5°). Maximum extension improved significantly (P<0.05) between pre-operative and post-operative measurements during standing (15.7 ± 6.8º vs 7.5 ± 6.4º), prone (14.5 ± 6.3 º vs 4.0 ± 4.8º), step-down (19.1 ± 7.3º vs 13.1 ± 7.5º), comfortable walk (16.6 ± 6.9º vs 8.4 ± 6.3º) and fast walk (16.3 ± 6.8º vs 7.8 ± 5.9º). There was no significant interaction between the effects of task and time for these functional tasks (F (1, 42) = 1.16, p = 0.284), suggesting that patients improved in a similar manner during all of these tasks.

Discussion:
Patients improve their ability to extend the knee following a TKR procedure, reducing the flexion contracture observed compared to the pre-operative measurement. Nevertheless, during all tasks patients still do not utilise the full amount of extension that was restored during the operation. Furthermore, while patients possessed the ability to extend the knee to approximately 4° flexion in a prone position, during functional tasks patients produced an average minimum flexion angle of 8-13°. This suggests that there are neuromuscular restraints being placed on the knee joint movement and this abnormal function may be a result of movement strategies used by the patient, rather than any physical constraint. Future work will focus on interventions during post-operative rehabilitation to improve the utilisation of extension during locomotion with the ultimate goal of improved rehabilitation guidelines and protocols for therapists.

**Conclusions:**
TKR patients utilise an improved amount of extension during static and functional tasks. The amount of improvement did not differ across the functional tasks. However, patients did not utilise the full amount of extension restored intra-operatively. These results highlight the importance of knee function during post-operative rehabilitation and may provide implications for improving the instruction of gait strategies during rehabilitation from TKR procedures.
Subchondral drilling with/without Collagen Augmentation in Patients undergoing High Tibial Osteotomy

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Abstract:

Purpose:
The quality of cartilage regeneration after marrow stimulation is well documented to be unpredictable, because they do not regenerate consistent amount of cartilage. To overcome the shortcomings of the subchondral drilling technique, various augmentation techniques using synthetic collagen matrix, scaffolds or plug devices have been developed. However, their efficacy remains unclear. The purpose of this prospective randomized controlled study is to evaluate whether the subchondral drilling in combination with collagen gel augmentation could improve the quality of cartilage regeneration in patients undergoing medial open wedge high tibial osteotomy (HTO) for the treatment of medial unicompartmental knee osteoarthritis (OA).

Methods:
We randomized twenty-four patients undergoing HTO in combination with subchondral drilling to receive either subchondral drilling alone (control group, n = 12) or subchondral drilling with collagen augmentation (experimental group, n=12). At postoperative one year, the clinical outcome in terms of Visual Analogue Scale of pain level (VAS), Knee Injury and Osteoarthritis Outcome Score (KOOS), International Knee Documentation Committee (IKDC) score, and Tegner scores were evaluated. In addition, second look arthroscopic examination and biopsy of regenerated cartilage were carried out when the HTO plate was removed. Biopsy specimens were graded by International Cartilage Repair Society Visual Assessment Scale (ICRS II scores). Finally, radiologic outcome in terms of Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) scores was assessed using follow up MRI undertaken.

Results:
The clinical outcomes in terms of pain VAS, KOOS, IKDC and Tegner scores were significantly improved in both groups without between-group differences (p > 0.1 in all comparisons). However, total ICRS II scores in the experimental group was higher than the control group (1079 and 892, respectively) (p = 0.005). Radiographic outcome basing on MOCART scores in the experimental group were higher than the control group on postoperative one year follow-up MRI (69 and 46, respectively) (p = 0.001).

Discussion and Conclusion:
The quality of chondrogenesis following subchondral drilling with collagen augmentation was superior to that of subchondral drilling only in patients undergoing HTO.
Osteochondral autograft transfer (OAT) combined with OWHTO for spontaneous osteonecrosis of the knee (SONK)

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a) Background We treated spontaneous osteonecrosis of the knee (SONK) with severe varus deformity by open wedge high tibial osteotomy (OWHTO) combined with osteochondral autograft transfer (OAT). We analyzed the postoperative clinical symptoms and the cartilage regeneration of medial femoral condyle.

b) Material Materials were 11 SONK patients of 11 knees (3 males and 8 females) of 69.9 years old in the average. All patients were treated by open wedge high tibial osteotomy combined with osteochondral autograft transfer. The implants were all Tomofix plates (Depuy Synthes) and the osteotomized bone gap was replaced by artificial bone (Superpore beta-TCP, HOYA PENTAX), then OATS system (Arthrex) was used for autograft.

c) Method All patients were assessed by age, sex, body mass index (BMI), postoperative alignment (FTA), lesion size, number of the transferred plugs. The clinical symptoms were assessed by Lysholm score before and after the surgery. The cartilage regeneration was assessed by second look arthroscopic evaluation using ICRS cartilage repair assessment score (protocol B) at the implant removal (14 months postoperatively in the average). We analyzed which factor significantly affected these results.

d) Results The average lesion size was 504mm, and the number of the transferred plugs were 3.6 in the average. The average postoperative femoro-tibial angle was 171 degrees. There were no cases of plug deviation nor displacement, and no case of recurrence of osteonecrosis. The average Lysholm score was improved from 54.8 points preoperatively, to 83.4 points postoperatively, and the scores were significantly improved in all cases. The ICRS assessment of cartilage defect (full score 4 points) was 3.7 points, plug integration (full score 4 points) was 3.7 points, and the macroscopic appearance (full score 4 points) was 3.0 points, and the total points (full score 12 points) was 10.4 in the average. All cases were graded Nearly Normal (total score 8-11). There were no significant relationship between the postoperative Lysholm score and the ICRS assessment score, and there were no factors among age, sex, BMI, the lesion size, and so on, which were affecting the assessment score.

e) Discussion There are many treatment options for spontaneous osteonecrosis of the
knee (SONK). Open wedge high tibial osteotomy (OWHTO) is one of the most popular joint preserving methods, but there were few reports describing whether the combination of osteochondral autograft transfer (OAT) was effective or not. This study demonstrated that osteonecrotic lesion replaced by osteochondral plug showed significantly good ICRS repair score. This implied that the osteochondral plugs were integrated well in the necrotic lesion in all cases, and that osteochondral defect was successfully repaired by regenerative fibrocartilage. We believed that OAT was the superior joint preserving method in the point that the subchondral bone and surface cartilage were simultaneously repaired in spite of the elder age of SONK patients. 

f) Conclusion The postoperative clinical results of OWHTO with OAT for SONK patients significantly improved in all cases, and the cartilage repair assessment score of SONK lesion were nearly Normal in all cases. Osteochondral autograft transfer was very good combination surgery with realignment tibial osteotomy to repair the osteochondral defect in SONK.
Results of Arthroscopic Fixation of Osteochondritis Dissecans Lesions of the Knee With Cylindrical Autogenous Osteochondral Plugs (case series)

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Purpose:
Surgical techniques that have been described for the operative fixation of an unstable osteochondritis dissecans (OCD) lesion in the knee are various and with different outcomes and none of them were totally successful. We report the results of a new fixation technique for unstable OCD lesions using arthroscopic autogenous osteochondral grafting (mosaicplasty).

Methods:
The OCD lesions were assessed arthroscopically and then fixed in situ by using one or multiple osteochondral dowel grafts harvested from the non weight-bearing region of femoral condyle. And all the patients were followed at least for 24 months.

Results:
Preoperative International Knee Documentation Committee scores assessed 4 patients as nearly normal, 10 as abnormal, and 2 as severely abnormal. After the 24-month follow-up, 15 knees were scored as normal and 1 patients as abnormal. All the patients had CT-scan after 6 months post operative and all of them had bony union. All the patients were symptom free at the last follow up.

Conclusions: Autogenous osteochondral grafting of unstable OCD lesions in the knee is a reliable technique for fixation of these lesions and in addition to have biologic enhancement of union with out any foreign body in the joint.
Arthroscopic Results of the Cartilage Repair using Fusion Technique of Island Osteochondral Autograft Transfer (OAT) and Microfracture for Severe Osteoarthritis in Younger Patients

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< Background >
Total knee replacements are generally selected for the treatment of severe osteoarthritis in which the joint space is completely or almost completely lost. However, the joint preserving procedures, such as cartilage repair and high tibial osteotomy (HTO), should be taken into account as an alternative for the patients who are the age of 60 or younger, because total knee replacements in younger patients can be followed by early revision surgery. The purpose of this study was to evaluate the arthroscopic results of the cartilage repair using fusion technique of island osteochondral autograft transfer (OAT) and microfracture which was performed for the patients who have suffered from severe osteoarthritis in their younger ages.

< Materials >
Among 149 knees which high tibial osteotomies and cartilage repair procedures were performed in Segyero hospital from Jan. 2011 to Dec. 2014, 43 knees were selected for this study. Inclusion criterion were patients who underwent high tibial osteotomy and cartilage repair with the above-mentioned fusion technique for ICRS Grade 4 lesion of medial femoral condyle, and then second look arthroscopy when the plate was removed after around 1 year postoperatively. Exclusion criterion were the patients of whom microfracture or OAT only was performed for medial femoral condylar lesion and the patients for whom second look arthroscopy was not performed

< Methods >
Surgical technique: After thorough arthroscopic examination of the joint, operative procedures, such as meniscectomy, synovectomy, and chondroplasty etc. were preformed. Microfracture was arthroscopically done for ICRS Grade 4 lesion of medial tibial plateau (MTP). Osteochondral autograft transfer of island pattern and microfracture was performed for ICRS Grade 4 lesion of medial femoral condyle (MFC) after abrasion of sclerotic subchondral bone through open wound. Finally, opening wedge HTO was done with the use of Puddu plate. Postoperatively continuous passive motion (CPM) exercise was encouraged 6-8 hours per day for 6 weeks.

The status of cartilage regeneration was identified by arthroscopic examination while removing the plate around 1 year postoperatively. We evaluated the regenerated cartilage about the lesion coverage, hardness, surface fibrillation, marginal integration into surrounding cartilage, and hypertrophy.

< Results >
The average age was 50.7 years (range: 39-60 years). Seven knees were for men, and thirty-six knees for women. The size of ICRS grade 4 lesion of MFC and MTP were 4.3 cm², 1.6 cm² in average, respectively. Better cartilage regeneration was noted in MFC lesion than in MTP lesion. For MFC Grade 4 lesion, it showed Grade 1 in 28 knees, Grade 2 in 14 knees, and Grade 3 in 1 knee on arthroscopic examination performed around 1 year postoperatively. Thirty-one knees had Grade 4 lesion in MTP. On postoperative arthroscopic examination for MTP Grade 4 lesion, it showed Grade 1 in 14 knees, Grade 2 in 8 knees, Grade 3 in 8 knees, and Grade 4 in 1 knee. During the second-look arthroscopy microfracture was performed in one knee due to small marginal delamination and 3 knees due to small uncovered area. Preoperatively radiologic findings demonstrated Kellgren - Lawrence grade 4 in 38 knees, Grade 3 in 5 knees. On Radiologic examination checked around 1 year postoperatively, there’s no knees with Grade 4, 14 knees with Grade 3, 25 knees with Grad 2, and 4 knees with Grade 1. Anatomic knee alignment preoperatively and postoperatively was 0 degree in average(range: -10 – 6.8 degrees ), 8.2 degrees in average(range: 2.5 - 13.7 degrees), respectively.

< Discussion >
It is well known that the microfracture can be effective for cartilage repair of contained lesion. Cartilage loss of the medial femoral condyles in severe osteoarthritis is usually not a contained lesion. However, the non-contained lesion in MFC can be changed into contained lesion through island OAT and abrasion of subchondral bone so that the microfracture can be effective. In addition, osteochondral graft inserted with island pattern will give the blood clot generated by the microfracture structural integrity to prevent certain damages from the shear stress.

< Conclusion >

Cartilage repair using fusion technique of OAT and microfracture could be a good alternative to TKR in severe osteoarthritis of younger patients as a salvage procedure. However, longevity of the cartilage regenerated by fusion technique of OAT and microfracture is still unknown. Therefore performing the procedure together with high tibial osteotomy would be desirable and long-term follow-up is required in the future.
Short-Term Clinical Outcome of Atellocollagen-associated Autologous Chondrocyte Implantation for the repair of chondral defects

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Introduction: A number of treatment procedures have been developed for chondral defects in the knee joint. The authors previously reported the prospective multicenter clinical trial of atellocollagen-associated autologous chondrocyte implantation (ACI) for the repair of full-thickness chondral defects of the knees. In this procedure, the clinical scores based on Lysholm scale and knee-function scale improved significantly. Therefore, this atellocollagen-associated ACI (JACC: Japan Tissue Engineering, Gamagori, Japan) is approved by the Japanese Health Insurance since 2013. The purpose of this study was to evaluate short-term clinical outcome and complication in patients undergoing atellocollagen-associated ACI for the repair of chondral defects of the knees.

Methods: Between 2014 and 2015, we prospectively evaluated the clinical outcome and magnetic resonance imaging (MRI) of transplanting autologous chondrocytes cultured in atelocollagen gel for the treatment of full-thickness defects of cartilage in five cases (five knees) with cartilage lesions on a femoral condyle. There were 5 men with a mean age of 40 years (range: 30-47). The patients were included in this study if (1) they had at least one knee full-thickness chondral lesion caused by trauma, or osteochondritis dissecans; (2) the chondral lesion had not been improved or was not expected to be improved by conventional treatments including arthroscopy, débridement, marrow stimulation technique, or autologous osteochondral transplantation; (3) the area of their chondral defect was ≥4 cm². The causes of the osteochondral defect were trauma (four knees) and osteochondritis dissecans (one knee). Concerning previous surgical procedures, osteochondral autologous implantation in one knee with osteochondritis dissecans. The lesions were on the medial femoral condyle in three knees and lateral femoral condyle in two knees. All cases underwent atellocollagen-associated ACI combined with; reconstruction of anterior cruciate ligament (ACL) in two knees, iliac bone graft in one knee, osteochondral autologous transplantation in one knee, reconstruction of lateral meniscus using semitendinous tendon in one knee. In surgical procedure, the patients underwent a two-stage procedure that included cartilage harvest and subsequent implantation of autologous chondrocytes embedded in atelocollagen gel. The cartilage biopsy was sent to a single facility (Japan Tissue Engineering), where chondrocytes were isolated from the cartilage biopsy, the engineered cartilage was prepared, and the chondrocytes were cultured to expand the cell population. The tissue-engineered cartilage was implanted 28 days. A medial or lateral parapatellar arthrotomy was carried out under tourniquet control. The chondral lesion was débrided as far as normal surrounding cartilage and until subchondral bone was visible. The defect was covered by a sutured periosteal flap after harvest of the
cartilage. The flap was shaped and sutured to the surrounding rim of normal cartilage. After suturing half of the border of the flap, the chondrocyte–atelocollagen gel was placed in the defect, and the remaining border of the flap was sutured. Two weeks after transplantation, continuous passive movement of the joint was begun. Partial weight bearing was introduced 3 weeks after surgery and was gradually increased to full weight bearing with muscle training during the first 6 weeks after surgery. We performed clinical and MRI examinations on these patients at before surgery and the latest follow-up periods after surgery (mean 8.8 months, range: 3-13 months). We also performed arthroscopic biopsy in two knees.

**Results:** The mean size of chondral defect was 4.2 cm$^2$ (range: 4-6 cm$^2$). The Lysholm score significantly improved from 73.5 points to 85.5 points. Regarding the Knee injury and Osteoarthritis Outcome Score (KOOS), the total score significantly increased from 65 points to 81 points. In one case, the graft was detached at 8 months after the implantation, and arthroscopic debridement was required. MRI evaluation demonstrated complete defect coverage in 4 cases. Defect filling was defined as complete in 4 cases, and the remaining 1 case had near-complete defect filling. 4 cases had an intact interface of the repair tissue and the adjacent femoral cartilage. A biopsy was performed at the site of chondral implantation in two case, and we confirmed cartilage-like tissue with a proteoglycan-rich matrix pathologically.

**Discussion:** This study demonstrated there was excellent short-term outcome of atellocollagen-associated ACI. However, the treatment failures were subsequently treated with graft removal in one patient, who had a marked hypertrophic response at the grafted site and then detachment of approximately half of the graft. This case had been performed osteochondral autologous implantation before atellocollagen-associated ACI, so the reason of detachment was thought to be osteosclerosis of the subchondral bone for implantation. We need additional follow-up of the cases in the present study.

**Conclusion:** The findings of the present study suggest that transplanting chondrocytes in a newly formed matrix of atellocollagen gel promotes restoration of the articular cartilage of the knee. There were few transplant failures, except for detachment of the graft in one case.
Background.
Autologous chondrocyte implantation (ACI) has limitations, and its position has been challenged by autologous bone marrow–derived mesenchymal stem cells (BMSCs). BMSCs have an added benefit as they require 1 less surgery, reduced costs, and minimized donor-site morbidity. This study was conducted to compare the 6-year clinical outcomes of patients treated with first-generation ACI to patients treated with BMSCs and to assess its feasibility as a replacement for ACI techniques.

Materials and Methods
Seventy-two matched (lesion site and age) patients underwent cartilage repair using chondrocytes (n = 36) or BMSCs (n = 36). Clinical outcomes were measured before operation and 3, 6, 9, 12, 18, 24 months and mid term outcomes were followed up till 6 years after operation. The International Cartilage Repair Society (ICRS) Cartilage Injury Evaluation Package, which included questions from the Short-Form Health Survey, International Knee Documentation Committee (IKDC) subjective knee evaluation form, Lysholm knee scale, and Tegner activity level scale were used for evaluation.

Results
At 6-year follow-up, there were 30 patients available for evaluation (ACI = 16, BMSC = 14), with a loss to follow-up rate of 58.3%. There was significant improvement in the patients’ quality of life (physical and mental components of the Short Form-36 questionnaire included in the ICRS package) after cartilage repair in both groups. However, there was no difference between the BMSC and the ACI group in terms of clinical outcomes.

The IKDC subjective knee evaluation (P = 0.258), Lysholm (P = 0.724), and Tegner (P = 0.827) scores did not show any significant difference between groups over time. Patients younger than 45 years of age scored significantly better than patients older than 45 years in the ACI group, but age did not make a difference in outcomes in the BMSC group.

Conclusion
BMSCs in cartilage repair is as effective as chondrocytes for articular cartilage repair. The mid term results suggest that BMSCs can be used in replacement for ACI as it provides the same effect at 6 years post intervention. In addition, it requires 1 less surgery, reduced costs, and minimized donor-site morbidity.