Category: Knee - Osteotomy

Postoperative Alignment and Its Relationship with Clinical Outcomes Following Double Level Osteotomy for Severe Varus Osteoarthritic Knees

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Summary:
Combined analysis of radiological and clinical results following DLO showed that large preoperative JLCA was a significant prognostic factor affecting the radiological and clinical outcomes. In cases with JLCA of 4° or more, accuracy of the deformity correction was impaired resulting in less optimal postoperative alignment.

Data:
Background: Double level osteotomy (DLO) has been indicated for symptomatic severe varus malalignment with the intent of restoring physiologic joint anatomy. However, there is a paucity of information regarding the efficacy of this procedure in attainment of physiologic alignment as well as the relationship between the pre-and postoperative radiological parameters and clinical outcomes. Purpose: To examine coronal alignment and bony geometry before and after DLO and their effects on the clinical outcome. Method: The study population was composed of 74 consecutive patients with mean age of 61.1 years (range, 45-76 years) who underwent DLO for severe varus osteoarthritic knees. DLO was adopted as a surgical option when there were combined varus deformities both in the distal femur and the proximal tibia. As for the intended limb alignment, the postoperative hip-knee-ankle angle (HKAA) was set to +1° valgus. The pre- and postoperative radiological and clinical data were retrospectively reviewed for the data acquisition and subjected to the analysis. All the patients could be followed up with for a minimum of 2 years. In the radiological evaluation, mechanical lateral distal femoral angle, mechanical medial proximal tibial angle, joint line convergence angle (JLCA) and HKAA were measured as parameters for the analysis. Outliers were defined as those with deviation of more than 3° from the intended postoperative HKAA (+1° valgus). The relationship between clinical outcomes using the Knee Injury and Osteoarthritic Injuries Score (KOOS) and radiological parameters were statistically assessed. Results: The radiological evaluation showed that the HKAA was corrected from 13.2° ± 3.0° varus to 0.5° ± 2.8° varus at 2 years after DLO, indicating slight undercorrection on average. Assessment of clinical outcome using the KOOS showed significant improvement from 185 ± 74 before surgery to 388 ± 72 at 2 years. As for the analysis of relationship among various radiological parameters, incidence of the postoperative outlier was significantly higher in patients with preoperative JLCA > 4° than those with JLCA < 4° (39.5% vs. 16.1%, p = 0.03). Correlation analysis between clinical score and postoperative alignment showed positive correlation between KOOS at 2 years and postoperative HKAA (r=0.47, p < 0.01), and the average KOOS at 2 years was significantly lower in the outliers than in the non-outliers (343 ± 62 vs 410 ± 57, p < 0.01). Conclusions: Combined analysis of radiological and clinical results following DLO showed that large preoperative JLCA was a significant prognostic factor affecting the radiological and clinical outcomes. In cases with JLCA of 4° or more, accuracy of the deformity correction was impaired resulting in less optimal postoperative alignment. Consequently, clinical outcomes were inferior in that group of knees.

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Computational Model of Slope Changing Tibial Osteotomy to Comprehensively Quantify Tibiofemoral Kinematics and ACL Loading

Abstract ID# 23455
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Summary:
We developed a technique to virtually assess the biomechanical impact of slope changing tibial osteotomy in a computational model to aid surgeons in selecting a target tibial slope in revision ACL reconstruction on a patient-specific basis.

Data:
Introduction Increased posterior-inferior directed slope of the tibial plateau (i.e., tibial slope) is related to elevated risk of ACL reconstruction failure [1]. Biomechanical studies link this risk factor for ACL graft tear to increases in both anterior tibial translation (ATT) and ACL graft force [2]. Therefore, some surgeons combine ACL graft revisions with anterior closing wedge high tibial osteotomy (ACWHTO) [3]. Too small of a correction, however, may not adequately reduce ACL forces while too large of a correction may increase PCL forces and elevate risk of injury to this ligament or cause knee recurvatum [4]. Unfortunately, the relationship between tibial slope and important biomechanical outcome measures such as cruciate ligament forces and tibiofemoral kinematics remains poorly understood. Thus, we had two goals. First was to develop a technique to conduct virtual tibial osteotomy in a computational knee model. Second was to quantitively sensitivity of ACL, PCL, and meniscal root forces and tibiofemoral kinematics to tibial slope changes. Methods A computer model of the tibiofemoral joint was developed from CT and MRI data of a right cadaveric knee of a 25-year-old female. Volumetric reconstructions of the tibia, femur, cartilage, and menisci along with the inserts of the cruciates, collaterals, capsular tissues, and peripheral and root attachments of the menisci were imported into the modeling pipeline. ACWHTO was simulated by removing a 10° wedge from the volumetric reconstruction of the tibia. The osteotomy was perpendicular to the sagittal plane and intersected the posterior-most aspect of the PCL. The computer models were loaded with 100 N compression and with loads simulating a clinical pivot shift maneuver consisting of serially applied compression (100 N), valgus (4 Nm), internal rotation (2 Nm), and an anterior force (30 N) at 15° of flexion. Outcomes measures were ATT, internal tibial rotation (ITR), and forces carried by the ACL and PCL and posterior roots of the menisci at the peak applied loads. Results With the simulated pivoting load, a 10° decrease in tibial slope caused a 63 N decrease and a 6 N increase in ACL and PCL force, respectively. The 10° decrease in tibial slope also decreased ATT by 7 mm and increased ITR by 2°. With isolated compression, the 10° decrease in tibial slope caused a 37 N decrease and an 8 N increase in ACL and PCL force, respectively, and a 7 mm decrease in ATT and 0.5° increase in ITR. Changes in posterior root forces of both menisci were minimal (≈5.4 N). Discussion We developed a technique to virtually assess the biomechanical impact of slope changing tibial osteotomy in a computational model. Model predictions of decreased ACL force and increased PCL force with reduced tibial slope corroborate cadaveric studies [2, 5]. This workflow could be used to determine cruciate forces and tibiofemoral kinematics to aid surgeons in selecting a target tibial slope on a patient-specific basis.

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Joint Line Obliquity (JLO) has an Independent and Significant Effect on Peak Lateral Compartment Compressive Load During Walking after Medial Opening Wedge High Tibial Osteotomy (HTO)

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Summary:
Joint line obliquity (JLO) has an independent and significant effect on peak lateral compartment compressive load during walking after medial opening wedge high tibial osteotomy (HTO).

Data:
Introduction: Medial opening wedge HTO unloads the medial tibiofemoral compartment (TFC) and increases loads on the lateral TFC. There is no consensus on acceptable limits for JLO after HTO (JLO > 4° (Babis et al., 2002) versus JLO > 10° (Coventry, 1987)). Apex proximal tibial osteotomy has been shown to increase compressive force on lateral compartment (Wang et al. 2021). This study aimed to quantify the independent effect of JLO versus Hip-Knee-Ankle
angle (HKA) on knee bicompartamental compressive loads during walking and guide surgical boundaries to HTO planning. We hypothesized that an increase in compressive load within the lateral TFC would have a direct relationship to post- HTO HKA but also to post-HTO JLO. Methods: 21 medial osteoarthritis patients (Surgery: Mean age, 50.9 ± 9 years old; height, 1.8 ± 0.1 m; mass, 99.6 ± 18.4 kg; BMI, 30.0 ± 4.6 kg/m2) underwent medial opening wedge HTO for treatment of osteoarthritis. Gait biomechanical data was collected with patients walking at normal speed (motion data, ground reaction force and muscle activity). Biomechanical and radiographic data were collected pre- and post- surgery to drive computer-simulated musculoskeletal models (Lerner et al., 2015). The radiographic data collected lateral distal femoral angle (LDFA), medial proximal tibial (MPTA) and HKA. JLO was the sum of LDFA and MPTA. Lower-limb muscle forces were computed using inverse dynamics and static optimization. Forces in the knee compartments were computed using Joint Reaction analyses (Steele et al., 2012). Computational pipeline determined the independent contribution of JLO and HKA on knee compartment loads during gait. Knee injury and osteoarthritis outcome score (KOOS) was also collected to evaluate surgery outcomes. Results: HKA was significantly more valgus after surgery (pre, 7 ± 3.8° versus post, 2.4 ± 1.6°; p < 0.05). KOOS was significantly improved 12 months after surgery (pre 46.9 ± 17.7; post 72.1 ± 17.9/52; p < 0.05). MPTA and JLO significantly after surgery (MPTA: pre 84.4 ± 2.8°; post 93.1 ± 2.3°; p < 0.05) and JLO: pre 173.7 ± 2.9°; post 182.0° ± 3.9°; p < 0.05). No difference in walking speed between pre (1.1 ± 0.12m/s versus post, 1.1 ± 0.15m/s; p < 0.05). Given a weak correlation between HKA and JLO (r = 0.57; p < 0.05), multiple regression was used to decode any confounding effect among these two variables. The isolated JLO effect (apex proximal) induced a 51.7N/m (r = 0.71; p < 0.05) peak compressive load change on lateral compartment at the first half of stance cycle. The isolated HKA effect (valgising) induced a 83.9N/m (r = 0.55; p < 0.05) and -76.5N/m (r = 0.63; p < 0.05) compressive load change on lateral and medial compartments at early stance, respectively. Conclusion: The increased compressive loads within the lateral TFC was explained by both the valgising HKA and apex proximal JLO. The decrease in compressive load within the medial compartment was only due to the valgising HKA. These results demonstrated that post-surgical JLO had a significant independent effect on lateral compartment load. HTO planning should consider not just HKA but also JLO to optimize lateral compartment loads and the potential impact on survivorship. Further analysis is necessary to provide clearer guidelines on appropriate boundaries for JLO to avoid compromising HTO outcomes.

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Is Implant Removal Necessary After Medial Open Wedge High Tibial Osteotomy?

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Summary:
Implant removal after MOWHTO reduced implant-related pain and improved Lysholm score and Tegner score. Even after implant removal, gap filling is gradually increased. No correction loss was found 2 years postoperatively in all patients. This results suggest that implant removal after MOWHTO is a valuable operative intervention.

Data:
Objective: There have been few studies that evaluated clinical and radiographic assessments after implant removal following medial opening wedge high tibial osteotomy (MOWHTO). The purpose of this study was to prospectively (1) to determine whether implant removal provides pain relief and functional improvement, (2) to investigate the progression of osteotomy gap filling on serial plain radiographs, and (3) to evaluate whether alignment correction could be maintained after implant removal following MOWHTO. Materials and Methods: MOWHTOs were performed without bone graft between March 2014 and September 2017. The guidelines for implant removal were (1) all patients received a recommendation to undergo elective implant removal after gap filling of more than 80% was observed at > 1 year follow-up, (2) the patients who ask for implant removal due to implant-related pain even though gap filling of less than 80% are permitted to undergo implant removal when postoperative time reaches 1 year. Patients with a minimum follow-up period of 2 years after implant removal were included in the present study. Implant-related pain was defined as either tenderness over the implant site or discomfort at the implant site with daily activities. The severity of implant-related pain was estimated using a visual analog scale on which 0 meant no pain, 1 to 3 meant mild pain, 4 to 6 meant moderate pain, and 7 to 10 meant severe pain. Clinical and functional evaluations were performed using Lysholm score and Tegner score. The gap filling rate was measured as the length of the newly formed bone among the overall length of the osteotomy. Postoperative alignment correction and its maintenance were assessed using four radiologic parameters: the weight-bearing line (WBL) ratio, the hip-knee-ankle angle (HKA), the medial proximal tibial angle (MPTA) and the posterior tibial slope angle (PTSA). Results: Sixty patients underwent MOWHTO during this study period, but five patients failed to follow-up for more than 24 months after implant removal. A total of 55 patients were enrolled in this study. 51 (92.7%) patients exhibited implant-related pain at implant removal (43 patients, moderate in 8 patients). At 1 and 2 years after implant removal, mild pain was 6 (10.9%) patients and 5 (9.1%) patients, respectively. The other patients had no implant-related pain. After implant removal, the Lysholm score improved from 77.0 ± 5.6 to 86.8 ± 5.7 (P < 0.05), and Tegner score improved from 3.3 ± 1.2 to 3.9 ± 1.3 (P < 0.05). However, there was no statistically significant difference between 1 year and 2 years after implant removal. At implant removal, the mean gap filling rate was 84.4% ± 9.6% (range, 60.1%–100%). At 1 and 2 years after implant removal, the mean gap filling rates increased to 93.7% ± 5.4% (75.7%–100%) and 97.4% ± 2.6% (85%-100%), respectively (P < 0.001). For the WBL ratio, MAA, MPTA, and PTSA no statistical differences were found between the follow-up radiographs performed at implant removal, 1 and 2 years after implant removal. Conclusion: Implant removal after MOWHTO provides reduced implant-related pain and improved functional scores. After implant removal, gap filling is gradually increased. No correction loss was found 2 years postoperatively in all patients.

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The Compensatory Theory in Proximal and Distal Joint Alignment and Gait in Varus Knee Osteoarthritis Treated With High Tibial Osteotomy: A Systematic Review

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Summary:
A systematic review into the proximal and distal joint alignment and gait in varus knee deformity in the younger arthritic patient demonstrates an inverse compensatory relationship in the hindfoot which reverts following high tibial osteotomy and may impact perioperative planning.

Data:
Background: Varus deformity is common in medial compartment knee osteoarthritis (OA). This coronal malalignment is compensated for by static and dynamic adjustments in the position of the adjacent joints, principally in the hindfoot & ankle. This condition can be treated in selected patients by high tibial osteotomy (HTO), stabilised with a fixed angle plate plate or circular frame, which may reverse these changes. The aim of this systematic review is to determine the evidence available for these compensatory mechanisms with the objectives being to improve deformity planning and optimise patient outcomes. Method: A systematic review with meta-analysis was designed using the PRISMA template to meet the research aim & objectives. Results: A total of 1,006 patients (1,020 knees), combined mean age 54.5 years, femoral angle ratio of 0.91, were extracted from 20 included studies. The methodologies of the majority of studies were at high risk of bias on the Newcastle-Ottawa Scale demonstrating significant heterogeneity. The combined mean change in the HKA axis was 7.7°; MPTA 7.4°; TT, 0.21°; T2 4.56° & AJLO 4° valgus. Conversely, preoperative hindfoot valgus compensation reverts towards neutral post-HTO. There is limited evidence available for a direct relationship between alignment and gait parameters. Conclusions: An inverse relationship between ankle and hindfoot alignment in varus deformity of the knee forms the basis of this compensation theory. In cases with significant hindfoot compensation, the reconstructive orthopaedic surgeon may consider angulation-translation HTO rather than the standard angulation-only approach, in order to optimise alignment.