IL6, FOS, and JUN gene expressions were downregulated, and the M2-macrophage-related CCL18 gene expression was upregulated. These results indicated a shift in gene profiles from M1 to M2 macrophages and downregulated inflammatory pathways. The KEGG pathway results showed downregulated inflammatory pathways, such as TLR signaling pathway, rheumatoid arthritis, TNF signaling pathway, cytokine-cytokine receptor interaction, and NF-kappa B signaling pathway. Real-time PCR determined that genes expressing pro-inflammatory IL1B and IL6, and M2 macrophage-related IL1RA, IL10, CCL18, and CD206 genes were respectively downregulated and upregulated. Histological findings with hematoxylin and eosin staining showed attenuated synovitis scores and immunofluorescence staining showed a shift from M1 to M2 macrophages. ELISA for SF showed only the concentration of interleukin-18 decreased after HTO. Cartilage fragments were less in the SF at plate removal than during HTO, and cartilage fragments, not humoral factor of SF, were responsible for M1 macrophage polarization and pro-inflammatory IL1B and IL6 expression in vitro primary human macrophages. Postoperative KOOS positively correlated with the expression of the M2-related genes CCL18 (r = 0.40) and CD206 (r = 0.36).

Conclusion: Correction of mechanical realignment altered the biological microenvironment of the knee joint. HTO is a joint preservation procedure that improves mechanical loading that changes inflammatory status in the knee joint and alters synovial macrophage polarization from M1 to M2, to a pro-healing phenotype.

Category: Knee - Osteotomy

A Fully Automated Artificial Intelligence for Lower Extremity Alignment Analysis – an Internal Validation Study in a Large Osteotomy Patient Collective

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All Authors: Marco-Christopher Rupp MD GERMANY
Felix Lindner cand. med. GERMANY
Yannick Ehmann MD GERMANY
Andreas B. Imhoff MD, Prof. Emeritus GERMANY
Sebastian Siebenlist MD, MBBS, Prof. GERMANY
Matthias Feucht Prof. GERMANY
Claudio von Schacky MD GERMANY
Nikolas Wilhelm MSc GERMANY

Summary: The developed artificial intelligence allowed for completely autonomous comprehensive analysis of the leg alignment on long leg radiographs with a high precision and reliability comparable to orthopedic surgeons.

Data: Background A comprehensive analysis of the leg alignment is paramount for the determination of an evidence-based treatment plan and the preoperative planning across a wide range of knee pathologies. A deep learning (DL) model that performs an automated analysis of the leg alignment on x-rays could accelerate the process currently performed by orthopedic surgeons (OS) and increase accuracy and reliability of preoperative planning. The purpose of this study was to train and validate a DL model for an automated assessment of the leg alignment on anterior posterior (a.p.) long leg radiographs (LLR) and compare the performance to OS in an internal validation study. Materials and Methods At the authors’ institution, a total of 594 patients (mean age 41.1 ±13.2 years, 182 female, 388 left side), who underwent corrective osteotomy, were enrolled. On a.p. LLRs, alignment analysis and placement of landmarks was performed by two OS (OS1 and OS2), serving as ground truth. Measurements included the mechanical femorotibial angle (mAFTA), lateral distal femoral angle (mLDFA), medial proximal tibia angle (mMPTA), lateral distal talar angle (mLDTA), joint line convergence angle (JLCA) and anatomical angle (AMA). The data set was split 60%(n=399)/10%(n=59)/30%(n=136) for training, validation, holdout testing. Twelve networks - each specialized on an anatomical region – were synthesized and angles were calculated. The model was based on a COCO pretrained Mask-R CNN-ResNeXt-101 implemented in PyTorch. The mean difference of the individual angles and the interreader reliability as quantified by the intraclass correlation (ICC) between the DL model and the ground truth were measured in the hold-out test set and to the performance of OS1 and OS2 to evaluate the performance of the DL model. Results The mean difference in the ICC between the DL model and the ground truth were 0.14 ± 0.11 and 1.0 [0.99, 1.0] for mAFTA, 0.66 ± 0.73 and 0.99 [0.98, 0.99] for mLDFA, 0.51 ± 0.81 and 0.95 [0.93, 0.97] for mLDTA, 0.65 ± 0.57 for mMPTA, 0.93 ± 0.86 and 0.95 [0.94, 0.97] for mLDTA, 0.86 ± 1.06 and 0.55 [0.42, 0.66] for JLCA and 0.34 ± 0.51 and 0.87 [0.82, 0.91] for AMA, respectively. In comparison, mean difference in the ICC between OS1 and OS2 were 0.07 ± 0.07 and 1.0 [1.0, 1.0] for mAFTA, 0.23 ± 0.28 and 0.97 [0.96, 0.98] for mLDFA, 0.19 ± 0.19 and 0.98 [0.98, 0.99] for mMPTA, 0.25 ± 0.25 and 0.98 [0.98, 0.99] for mLDTA, 0.64 ± 0.93 and 0.38 [0.22, 0.52] for JLCA and 0.14 ± 0.14 and 0.94 [0.92, 0.96] for AMA, respectively. The DL model outperformed the OS in the time required for the analysis (22.4 ± 5.5s vs. 91.0 ±10.6s).

Conclusion: The developed DL model allowed for complete autonomous comprehensive analysis of the leg alignment on a.p. LLR with a high precision and reliability comparable to orthopedic surgeons, while DL model significantly outperformed human raters in the time taken for assessment.

Category: Knee - Osteotomy

Larger Pre-operative Tibial Bone Marrow Lesion Volume Correlates with Better Clinical Outcomes after Medial Opening High Tibial Osteotomy

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All Authors: Kohsei Nishitani MD, PhD JAPAN
Taisuke Yabe MD JAPAN
Shinichi Kuriyama MD, PhD JAPAN
Shinichiro Nakamura MD, PhD JAPAN
Shuichi Matsuda MD, PhD JAPAN

Summary: Larger pre-operative BML volumes positively correlated with some post-operative KOOS subscales and with many delta KOOS subscales. Pre-operative large BML had no negative influence on post-operative clinical outcomes; hence, surgeons need not hesitate to perform MOWHTO in patients with large BMLs in the medial condyles.

Data: Purpose There is insufficient evidence regarding the indications of MOWHTO in patients with large pre-operative bone marrow lesion (BML). To this end, this study evaluated modern medial open-angle high tibial osteotomy (MOWHTO) clinical outcomes and bone marrow lesion (BML) scores and volumes. We hypothesized that BML volume is more associated with clinical outcomes of MOWHTO than qualitative BML evaluations, and that BML volume is correlated with the improvement of clinical outcomes. Methods Patients who underwent MOWHTO for osteoarthritis or spontaneous necrosis of the knee between 2018 and 2021 were enrolled retrospectively. Knee Injury and Osteoarthritis Outcome Score (KOOS) was recorded before the initial surgery and at plate removal surgery. Pre-operative BMLs were evaluated using three qualitative scoring systems, reflecting the maximum length, proportion, and intensity of the BML. For quantification, BMLs of the femur and tibia were separately defined as the area with a threshold more than the mean signal intensity plus two standard deviations, using the corresponding lateral condyles as controls. BML volumes were then calculated by the integration of BML in each slice. Association between KOOS total/subscores and BML scores/volume was evaluated with Spearman’s correlation. Spearman’s correlation between BML volumes and Lysholm knee and Tegner activity scores were also calculated. Finally, multivariate linear regression analysis for the post-operative KOOS total was performed using a backward-stepwise approach to minimize the Akaike information criterion. Results Forty-three cases (24 females and 19 males, age: 61.5 ± 7.4 years old) of MOWHTO were included in the final analysis. No significant correlations between qualitative BML scores and pre-operative, post-operative, and delta KOOS were found, except one BML score each which correlated with pre-operative KOOS scores or with post-operative KOOS ADL. Femoral BML volume did not correlate with pre-operative, post-operative or delta- KOOS total, but tibial BML volume weakly correlated with delta KOOS total (r = 0.33, p = 0.03). For KOOS subscales, femoral BML volume were correlated with post-operative KOOS ADL (r = 0.36, p = 0.02) and KOOS QOL (r = 0.50, p = 0.007), and tibial BML volume were correlated with post-operative KOOS ADL sports (r = 0.38, p = 0.01). Tibial BML volume was significantly correlated with all five delta KOOS scales (r = 0.37 to 0.51, p = 0.02 to 0.007), however, femoral BML volume was only correlated with delta KOOS QOL (r = 0.41, p = 0.009). The femoral and tibial BML volumes were moderately (r = 0.42, p = 0.006) and weakly (r = 0.36, p = 0.02) correlated with delta Lysholm knee scores, respectively, while BML volumes did not correlate with Tegner activity scores. Conclusion Larger pre-operative BML volumes positively correlated with some post-operative KOOS subscales and with many delta KOOS subscales. Pre-operative large BML had no negative influence on post-operative clinical outcomes; hence, surgeons need not hesitate to perform MOWHTO in patients with large BMLs in the medial condyles.