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OP0061

FEASIBILITY STUDY ON AN AUTOMATED QUANTITATIVE SYSTEM FOR ULTRASOUND JOINT INFLAMMATION ASSESSMENT IN RHEUMATOID ARTHRITIS USING DEEP LEARNING

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Background: The most widely accepted ultrasound (US) joint inflammation scoring system in rheumatoid arthritis (RA) is semi-quantitative in nature. This process involves manual image acquisition followed by image interpretation. The subjectivity inherent in manual scoring may be overcome by the development of an automated quantitative system to measure joint inflammation.

Objectives: To develop an automated quantitative system to measure US detected power Doppler (PD) joint inflammation in patients with RA.

Methods: The synovial region of interest (sROI) on US images at the metacarpophalangeal joints (MCPJs) and the metatarsophalangeal joint (MTPJs) within the Doppler box is manually segmented by a clinician experienced in musculoskeletal US (figure 1). PD joint inflammation was scored manually semi-quantitatively (0-3). Deep learning based image segmentation was applied to the US images to automatically identify sROI and quantify the amount of PD signals within the sROI (figure 1) to obtain a computer derived PD reading reflecting the extent of PD vascularity within the sROI. The performance of computer derived PD reading was evaluated in comparison with the clinician's manual scoring.

Results: 820 joints from bilateral 1st to 5th MCPJs and MTPJs in 41 adult RA patients (baseline characteristics: 75.6% Chinese; 73.2% female; mean (SD) DAS28, 4.23 (1.25); mean (SD) disease duration, 73.3 (57.8) months) were evaluated in this cross-sectional study. The respective mean (SD)/ median (IQR) computer derived PD readings were 0.13 (0.75)/0.04 (0.08), 1.62 (1.77)/1.21 (1.19) and 10.12 (6.86)/7.51 (5.24) for manual score 0, 1 and 2 (no joints had manual score 3), with statistically significant differences found among the different manual score classes (for non-normally distributed data, Kruskal-Wallis

Figure 1. Manual and automated segmentation of synovial region of interest

Table 1. Performance of computer prediction versus clinician evaluation

Score 0 vs. 1		
Assessor	Clinician Evaluation: Score 0	Clinician Evaluation: Score 1
Computer Prediction: Score 0	615	1
Computer Prediction: Score 1	19	115
Sensitivity=99.14%, Specificity=97.00%		
Score 1 vs. 2		
Assessor	Clinician Evaluation: Score 1	Clinician Evaluation: Score 2
Computer Prediction: Score 1	109	2
Computer Prediction: Score 2	7	68
Sensitivity=97.14%, Specificity=93.97%		

H-test, $p=1.69 \times 10^{-92}$, Mann-Whitney Test: manual score 0 versus 1, $p=1.04 \times 10^{-62}$; manual score 0 versus 2, $p=3.28 \times 10^{-43}$; manual score 1 versus 2, $p=1.53 \times 10^{-28}$). Area under the ROC curve (AUC) based on computer derived PD reading cut-off of 0.26 to identify manual score 0 versus 1 was 0.98, while AUC based on computer derived PD reading cut-off of 3.37 to identify manual score 1 versus 2 was 0.98. The overall agreement of the score classes (0, 1 and 2) based on computer prediction using the above cut-offs versus manual scores of 0, 1 and 2 is 791/820=96.46%. Table 1 summarizes the performance of computer prediction using the above cut-offs when compared to clinician evaluation (i.e. score 0 versus 1, comparing computer prediction with clinician evaluation, sensitivity=99.14% and specificity=97.00%; score 1 versus 2, comparing computer prediction with clinician evaluation, sensitivity=97.14% and specificity=93.97%).

Conclusion: An automated quantitative system for US PD joint inflammation using deep learning showed high sensitivity and specificity when results from computer prediction were compared to clinician evaluation. Further validation in a larger RA cohort with a longitudinal study design would be required.

References: Nil

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OP0062

PREDICTIVE VALUE OF BONE TEXTURE FEATURES EXTRACTED BY DEEP LEARNING MODELS FOR THE DETECTION OF OSTEOARTHRITIS: DATA FROM THE OSTEOARTHRITIS INITIATIVE

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Background: Osteoarthritis is a degenerative disorder characterized by radiographic features of asymmetric loss of joint space, subchondral sclerosis, and osteophyte formation. Conventional plain films are essential to detect structural changes in osteoarthritis. Recent evidence suggests that fractal- and entropy-based bone texture parameters may improve the prediction of radiographic osteoarthritis.¹ In contrast to the fixed texture features, deep learning models allow the comprehensive texture feature extraction and recognition relevant to osteoarthritis.

Objectives: To assess the predictive value of deep learning-extracted bone texture features in the detection of radiographic osteoarthritis.

Methods: We used data from the Osteoarthritis Initiative, which is a longitudinal study with 4,796 patients followed up and assessed for osteoarthritis. We used a training set of 25,978 images from 3,086 patients to develop the textual model. We use the BoneFinder software² to do the segmentation of distal femur and proximal tibia. We used the Deep Texture Encoding Network (Deep-TEN)³ to encode the bone texture features into a vector, which is fed to a 5-way linear classifier for Kellgren and Lawrence grading for osteoarthritis classification. We also developed a Residual Network with 18 layers (ResNet18) for comparison since it deals with contours as well. Spearman's correlation coefficient was used to assess the correlation between predicted and reference KL grades. We also test the performance of the model to identify osteoarthritis (KL grade $\geq$ 2).

Results: We obtained 6,490 knee radiographs from 446 female and 326 male patients who were not in the training sets to validate the performance of the models. The distribution of the KL grades in the training and testing sets were shown in Table 1. The Spearman's correlation coefficient was 0.60 for the Deep-TEN and 0.67 for the ResNet18 model. Table 2 shows the performance of the models to detect osteoarthritis. The positive predictive value for Deep-TEN and ResNet18 model classification for OA was 81.37% and 87.46%, respectively.

Table 1. Distribution of KL grades in the training and testing sets.

KL grades	0	1	2	3	4	Total
Training set	10893	4582	6114	3320	799	25,978
	41.9%	18.7%	23.5%	12.8%	3.1%	
Testing set	2472	1353	1696	775	194	6,490
	38.1%	20.8%	26.1%	11.9%	3.0%	

Table 2. Performance matrices of the Deep-Ten and ResNet18 models to detect osteoarthritis

	Deep-TEN	ResNet18
Sensitivity	62.29% (95% CI, 60.42%–64.13%)	59.14% (95% CI, 57.24%–61.01%)
Specificity	90.07% (95% CI, 89.07%–91.00%)	94.09% (95% CI, 93.30%–94.82%)
Positive predictive value	81.37% (95% CI, 79.81%–82.84%)	87.46% (95% CI, 85.96%–88.82%)
Negative predictive value	77.42% (95% CI, 77.64%–79.65%)	76.77% (95% CI, 75.93%–77.59%)

Conclusion: This study demonstrates that the bone texture model performs reasonably well to detect radiographic osteoarthritis with a similar performance to the bone contour model.

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OP0063

QUANTITATIVE COMPUTED TOMOGRAPHY PREDICTS 10-YEAR MORTALITY IN INTERSTITIAL LUNG DISEASE RELATED TO SYSTEMIC SCLEROSIS

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Background: Interstitial lung disease (ILD) is the main cause of death in Systemic Sclerosis (SSc). Chest CT is the gold standard in detecting ILD although it is not easy to understand its prognostic value. ILD qualitative assessment is almost worthless. Goh et al. semi quantitative score of ILD extent is related to mortality risk but it is burdened by relevant inter/intra-readers variability. An operator independent algorithm based on voxel-wise analysis proved to identify SSc patients with an increased risk of mortality according to prediction models.

Objectives: To verify if quantitative analysis of chest CT (QCT) predict 10 years-mortality in SSc patients.

Methods: SSc patients with availability of a chest CT were enrolled in 13 different centers. The CT voxel-wise analysis with a free software (www.horosproject.com) provided QCT indexes: kurtosis, skewness, mean lung attenuation and standard deviation. Patients characteristics, autoimmune profile and pulmonary function test were collected. The follow-up interval lasted from the date of chest CT to the one of the last visit or death. Each QCT index cutoff, established in a previous study (1), clustered patients in two groups. Kaplan-Meier analysis estimated and compared survival in the above mentioned groups. $p < 0.05$ was considered statistically significant.

Results: Five hundred sixty three SSc patients were enrolled (35938 patient-months); 52.4% had ILD detectable at CT scan. For each QCT index cutoff the cohort was split in two subgroups without differences in terms of sex, age, disease duration, autoimmune profile. All QCT indexes' cutoff selected subgroups with statistically different survival rate (e.g in Figure 1).

Figure 1

Conclusion: QCT can arise as the new gold standard in identifying SSc patients with poor prognosis. The real possibility to stratify SSc subjects according mortality risk will have a pivotal role in ILD treatment decisional process with the incoming anti-fibrotic drugs.

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OP0064

AUTOMATIC SCORING OF ARTHRITIS DISEASE ACTIVITY ON ULTRASOUND IMAGES FROM RHEUMATOID ARTHRITIS PATIENTS WITH CASCADED CONVOLUTIONAL NEURAL NETWORKS

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Background: Systematic Power or Color Doppler (CD) ultrasound (US) of joints can be used for early detection of Rheumatoid Arthritis (RA), predicting radiographic progression and early detection of disease flare in established