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Knee osteoarthritis grading by resonant Raman and surface-enhanced Raman scattering (SERS) analysis of synovial fluid☆,☆☆

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Abstract

In this preliminary study on synovial fluid (SF), knee osteoarthritis (OA) grading of n = 23 patients was accomplished by combining two methods: resonant Raman spectroscopy, and surface-enhanced Raman scattering (SERS) of native proteins acquired with iodide-modified silver nanoparticles and a laser emitting at 633 nm. Based on principal component analysis–linear discriminant analysis (PCA–LDA), the SERS spectra of proteins enabled the classification of low-grade and high-grade OA groups with an accuracy of 91%. Resonant Raman spectra of SF, recorded with laser excitation at 532 nm, exhibited carotenoid-associated bands that were less intense in the case of high-grade knee OA patients. Based on the resonant Raman spectra, the grading of OA patients was accomplished with an accuracy of 74%. Concatenating SERS and Raman spectral information increased the classification accuracy between the two groups to 100%. These results demonstrate the potential of Raman and SERS as a point-of-care method for aiding OA grading.

Key words: Osteoarthritis; PCA–LDA; Raman spectroscopy; SERS; Synovial fluid

Osteoarthritis (OA) is a group of distinct joint disorders with overlapping biological, morphological and clinical outcomes, which represents the most prevalent joint disease in developed countries. OA affects approximately 15% of the population in Europe and North America and its prevalence is expected to rise due to the aging of population.[1,2] Several lines of evidence suggested that OA should not be regarded solely as a disease of the cartilage, but rather as a global condition of the joint, equally affecting subchondral bone, ligaments and synovial fluid (SF).[3] Risk factors for OA include a large set of heterogenous genetic and environmental factors, which trigger and then contribute to disease progression. However, the exact molecular mechanism behind OA is not completely understood. For instance, some genetic risk factors are location-specific (e.g. for knee or hand OA), a finding which suggests that OA represents a clinical diagnosis comprising several entities with distinct molecular mechanisms.[4,5]

The diagnosis of knee OA is based on clinical and imaging findings and for the moment, there are no specific biomarkers aiding early diagnosis. Extensive metabolomic studies of SF and serum found that branched-chain amino acids (valine and leucine)[6] or arginine[7] were up-regulated in osteoarthritic

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